DEVELOPING METHODS FOR THE ESTIMATION OF STATURE AND THEIR USE AS A PROXY FOR HEALTH AMONG THE ANCIENT CHACHAPOYA OF PERU

by

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ABSTRACT

Population mean stature and patterns of health are often linked in anthropological studies, yet few studies control for the multifactorial nature of achieving adult standing height. This thesis explores the intersection of health and stature by analyzing the skeletal remains of 161 adult individuals from the archaeological site of Kuelap, in the eastern slopes of the northern Peruvian Andes, and also tests current biometric methods for estimating stature from skeletal remains. This Chachapoya site dates to the Late Intermediate Period (AD 900 – 1470) and Late Horizon (AD 1470 – 1536) and resides in the high altitude sub-tropical forests of the Andes. An anatomical method of stature estimation was applied to a subsample of 36 individuals and linear regression formulae were created, proving especially effective for the tibia and calcaneus in this sample. These new formulae produced more accurate results, regardless of sex, when compared to traditional estimates and suggest that sexually specific formulae are not necessary in studies of stature. However, sexual dimorphism in skeletal elements did produce an effective method of sex determination from individual appendicular elements and was tested successfully on commingled remains. This investigation produced valuable formulae for estimating both sex and stature from isolated remains in the Chachapoyas region. The results established that interregional variance in stature is consistent, but mean stature is strongly affected by environmental pressures. This study highlights the ineffectiveness of using stature to assess the relative health of geographically distinct populations, but demonstrates the possibility of culturally specific health interpretations. The formulae for sex and stature estimation created in this study have provided a glimpse of the intersection between culture, environment, and health in human biological diversity.

To my rock, my partner, and my best friend

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LIST OF ABBREVIATIONS

AD = Anno Domini also known as Current Era
BLF = Bicondylar Length of the Femur
BP = Before Present (calibrated to 1950)
CLT = Condylar-Malleolar Tibial Length
DHB = Humeral Distal Breadth
DTB = Tibial Distal Breadth
FDB = Femoral Distal Breadth
FHD = Femoral Head Diameter
HAP = Humeral Anterior-Posterior Diameter
HHD = Humeral Head Diameter
HML = Humeral Medio-Lateral Diameter
LRF = Linear Regression Formula for the estimation of adult standing height
m.a.s.l = Meters Above Sea Level
MBC = Maximum Calcaneal Breadth
MR = Multiple Regression
OLS = Ordinary Least Squares method for linear regression
SAC = Sierra Colorada archaeological site
SD = Standard Deviation
SEE = Standard Error of Estimate
SPA = San Pedro de Atacama archaeological site
TEM = Technical Error of Measurement
TPB = Tibial Plateau Breadth
XLC = Maximum Length of the Calcaneus
XLF = Maximum Length of the Femur
XLH = Maximum Length of the Humerus

CHAPTER ONE: INTRODUCTION

Human beings, when viewed in their totality, exhibit an impressive array of variation in their physical form, which correlates with our ability to adapt to diverse environments. One of the most notable aspects of this variation is stature, or standing height, which can range from very short individuals such as the Efe pygmies from Africa to very tall individuals such as many modern Dutch Europeans (Baten and Blum, 2012; Bogin and Varela-Silva, 2010; Dietz et al., 1989). Our ability to observe this variation globally allows us to take it for granted, but the range of stature within regional populations in the ancient world have been understudied. Studying archaeological populations allows researchers to examine temporal trends in health as adult stature is often used as a proxy for the overall health of a population (Bogin and Varela-Silva, 2010; Byers, 1994; Goodman and Martin, 2002; Peck, 2013). Yet, growth and development of the skeleton until the achievement of adult standing height is a highly complex process involving both extrinsic and intrinsic factors, and direct comparisons of mean stature between different regions to examine health patterns are unreliable; thus, intraregional variation of ancient populations must be examined in order to control for environmental, genetic, and temporal variables. The purpose of this research is to explore regional human stature variation and its intersection with health through the analysis of long bone biometrics of the ancient Chachapoya people of Peru (ca. AD 900 – 1535).

The four objectives of this study include: 1) the exploration of intraregional variation in stature, 2) the effect of inter-regional variation in the application of stature estimation formulae, 3) the use of stature as a proxy for health in ancient populations, and 4) the examination of sexual dimorphism and its effect on stature variation.

Human Variation in Stature

In our globalized society, large variation in adult standing height is not unexpected since we can observe individuals from vastly different regions simultaneously. The World Health Organization (WHO) provides growth charts that include within normal variation stature ranges of 163 – 190 cm for males and 151 – 175 cm for females in adult individuals (19 years; 97% percentile interval). In ancient populations, however, stature appears to have varied less and ratios of long bones to stature have been found to be unique within a given geographic region (Béguelin, 2011; Haviland, 1967; Lukacs et al., 2014; Mummert et al., 2011; Pomeroy and Stock, 2012; Raxter et al., 2008; Zakrzewski, 2003). This can be explained through environmental, nutritional, and genetic homogeneity as a result of minimal migration in the ancient world. Thus, population specificity requires that analyses of stature investigate differences within regional groups.

Adult stature is affected during growth and development by both intrinsic and extrinsic factors (Table 1). Some scholars have argued for effects of extrinsic factors during growth and development as being more impactful on adult stature than genetics (Becker et al., 2012; Bogin and Varela-Silva, 2010; Cámara, 2015; Wolański, 1979). Surprisingly little data have been published on the expected range in skeletal variation within ancient regional groups (Stock and Willmore, 2003; Weinstein, 2005). In order to explore the health of a region using stature as a proxy, researchers must first understand what is expected in the skeletal morphology of the local individuals under the assumption of limited gene flow in ancient regional populations.

Another important aspect to consider about stature is the marked sexual dimorphism in some human populations. While humans in general are less sexually dimorphic than other primates, some differences do exist between males and females in almost every population, with males being on average 7-8% larger than females but varying depending on region and cultural practices (Bogin and Varela-Silva, 2010; Byers, 2011; Frayer, 1980; Holden and Mace, 1999; Wells, 2012). Therefore, any examination of regional variation of long bone morphology must examine sexual dimorphism. These skeletal differences between the sexes are generally most visible after puberty, and thus any analysis of sexual dimorphism and juvenile remains is inherently limited (Byers, 2011; Rösing et al., 2007). All of these factors affect the study of human variation, adaptation, and health in past societies, and are addressed in the following chapters.

Table 1: Summary of intrinsic and extrinsic factors which affect growth and development and influence adult stature.

Intrinsic Factors	**Extrinsic Factors**
Genetic Potential	Climate
Sexual Dimorphism	Altitude
	Stress and Pathology
	Nutrition

Bioarchaeology and Human Biological Diversity

Bioarchaeology is defined as a multidisciplinary approach that seeks to understand the human past through the physical human remains and the cultural contexts in which these remains are found (Buikstra and Beck, 2006; Walker, 2008a). This specialization allows researchers to explore human biology as it changes through time in order to examine trends in human evolution and adaptation as well as overall health (Agarwal, 2012; Brickley and Ives, 2010; Knudson and Stojanowski, 2008). Some scholars have suggested that bioarchaeological investigators define health too broadly, leading to mistaken conclusions (Temple and Goodman, 2014); thus, many bioarchaeological studies reference regional populations and local life histories in order to minimize these errors (Roksandic and Armstrong, 2011; Wright and Yoder, 2003). For this study, health is defined as the absence of skeletal stress indicators on an individual when compared within a geographic population. This relative definition allows the application of health as a parameter for study while mitigating issues associated with broadly defining health, and neglecting environmental and cultural factors that affect human biology (McIlvaine and Reitsema, 2014; Temple and Goodman, 2014; Wood et al., 1992).

Unfortunately, few bioarchaeological studies actually address regional anthropometric variation when using stature estimated from skeletal remains as a proxy for the health of a population (Agarwal, 2012; Bush, 1991; Goodman and Martin, 2002; Peck, 2013). This dichotomy leads to concerns over the misrepresentation of a population as “healthy” or “unhealthy” without meaningful comparative data. Comparisons of stature either do not control for inter-regional differences or they provide no intra-regional baseline for a discussion on relative “health”. This study provides a baseline for the regional variation of a single population, thereby addressing some of the issues associated with stature as a generalized proxy for health in future bioarchaeological investigations.

The estimation of living stature from the skeleton is often used in bioarchaeological studies as one of the common descriptive factors of a population since it has the ability to convey information on physical adaptations to the environment, descent, and health and its easy calculation from complete long bones (Becker et al., 2012; Byers, 1994; Haviland, 1967; Vercellotti et al., 2014; Zakrzewski, 2003). Since soft tissue is no longer present in a majority of bioarchaeological studies, stature can be estimated using one of two methods using various skeletal elements: 1) linear regression formulae (LRFs) from a single element, or (2) Anatomical approximations (Fully technique) using multiple elements and calculating a skeletal height (Ousley, 1995; Pomeroy and Stock, 2012; Raxter et al., 2006; Raxter et al., 2008). This study explores the use of these various methods in stature estimation for the ancient Chachapoya population by first using the Anatomical method on a known sample and then applying an ordinary least squares (OLS) linear regression to create an LRF for this study sample.

The Chachapoya Region and People

Although archaeological interest has grown in the region in recent years, the ancient Chachapoya culture is still relatively little studied. The Chachapoya people inhabited the eastern slopes of the Andes facing the Amazonian basin (Church and von Hagen, 2008). The socio-political organization of the Chachapoya culture is still debated. While some scholars have argued that the Chachapoya were a collection of village-centered communities that only came together to repel external threats (specifically the Inca) (Church and von Hagen, 2008; Schjellerup, 1997), others have interpreted them to have been a centralized polity (Narváez, 1987). Through the investigation of the human remains from archaeological sites in conjunction with their archaeological data, researchers can gain a glimpse of the lives of these people and thereby understand some of the socio-cultural effects on their biology.

Previous research has suggested that the population of Kuelap, a major site in the Chachapoyas region, was generally homogeneous, thus controlling for genetic diversity and its effect on adult stature (Nystrom, 2006). Controlling for these factors allows a more meaningful exploration of the expected variation within an isolated regional population, making the Chachapoya sample at the site of Kuelap an excellent study sample. Thus, the material for the examination of normal human variation in this region was collected from two sites which contained relatively well-preserved skeletal remains, Kuelap and La Petaca.

The site of Kuelap is a monumental citadel located on a ridge top (3,000 meters above sea level [m.a.s.l.]) 35 km south of the modern town of Chachapoyas (Narváez, 1987). The site encompasses 4.5 km^2, with over 400 residential structures, retention walls achieving a maximum constructive height of 20 m, and has been interpreted as an important site in the ancient Chachapoya region and culture (Church and von Hagen, 2008; Narváez, 1987; Nystrom and Toyne, 2014). From this site, a collection of well-preserved skeletal remains representing over 600 individuals, males, females, and subadults, has been recovered. La Petaca is a mortuary complex located 14 km southwest of the modern town of Leymebamba. It is a massive natural rock wall with 124 structures over a façade of 12,000 m^2 and an occupation that spans over 600 years (Gonzalez and Toyne, 2014; Toyne and Anzellini, *in press*). From this site, only collective, disturbed burials from a natural mortuary space were examined in order to test the methods created in this study. Over 7,000 skeletal elements representing a minimum of 55 individuals have been recovered and are available for study.

Research Questions and Hypotheses

Exploration of anthropomorphic variation in ancient skeletal morphology requires controlling for various variables that may affect individuals during their growth when possible. The sample of ancient Chachapoya skeletons allow for some degree of control of genetic and environmental factors, and provide a more reliable baseline for this study of expected variation in stature. This research explores the variation in stature within the region, between regions, and the intersection of sexual dimorphism, health, and environmental pressures affecting stature.

Therefore, this research seeks to examine the following questions:

1. How tall were the ancient Chachapoya? Are regression formulae based on distant reference populations appropriate for estimating standing height in the Chachapoya region from incomplete individuals? Must anatomical estimations always be used for proper accuracy?
2. What is the morphological variation in stature of the ancient Chachapoya? Is this range in variation comparable to that found at other Andean sites?
3. Can we use a known sex sample to create a reliable logistic regression for determining the sex of isolated long bones in the Chachapoya region? Is sexual dimorphism significant in stature estimations? Do all regions demonstrate patterns of significant sexual dimorphism?
4. What does the observed variation in appendicular metrics potentially indicate about Chachapoya environment, adaptation, and culture? Could increased variation, when compared to other Andean regions, reflect poor health, differences in social organization, or differing subsistence patterns?

These questions may be examined by testing the following hypotheses using the collected skeletal data:

- i. If stature regression formulae based on distant reference populations provide stature estimates that are not significantly different from anatomical estimates, then stature may be used as a comparative measure of health across different regions.
    - a. If anatomical stature estimates are significantly different from regression formulae based on distant reference populations, then stature cannot be used as an interregional measure of health.

ii. If sexual dimorphism in Chachapoyas is significant in postcranial remains and can be determined from such, then the application of regression formulae must consist of separate formulae for each sex.
    a. If sexual dimorphism is not significant in Chachapoya postcranial remains, or if sex cannot be determined from those remains, then sex is not an important factor in the application of stature estimate regression formulae.

iii. If the range in variation within the Chachapoya population is significantly different from the variation found in other Andean populations, then this difference might be the result of social complexity due to differential health.
    a. If the range in variation is not significantly different from other Andean populations, but mean values differ, then the effects of altitude and subsistence strategy may play a larger role in the attainment of adult stature.
    b. If neither the range nor mean values are significantly different, then environmental pressures in the Andean region must have a negligible effect on standing adult height.

Organization of this Thesis

I begin this thesis with Chapter Two, in which I discuss human variation in physical form, specifically stature and the various factors that may affect this trait, the significance of stature and sex in bioarchaeological analyses. I include the issues associated with the use of stature as an indicator of health, the inextricability of sex and stature and the various methods that have been used to estimate both in the archaeological record. I review the background on previous research conducted in the Chachapoyas region, and specifically at the two sites of interest for this study. Chapter Three presents the materials that were sampled for this study, the methods of data collection, and the analytical testing used in the exploration of the dataset. Chapter Four discusses the results of this study organized into sections defined by the three hypotheses previously presented in this chapter. I interpret the results of these analyses in Chapter Five, including their significance to stature in the Andes, specifically the Chachapoya, and the applicability of the methods created in this study. I, then, place these results within the broader context of anthropological research and the implications for the scientific understanding of physical adaptation, biocultural adaptations, and the effects of environmental and cultural pressures on human physical form. Finally, Chapter Six provides the conclusions and limitations of this research as well as the future considerations for bioarchaeological and anthropological research.

CHAPTER TWO: ANTHROPOLOGICAL BACKGROUND

In this chapter I explore published literature on stature, sex estimations of skeletal remains, Andean physical geography, and more specifically the Chachapoya region and people. First I engage with the modern discussion of human variation and diversity in physical form as well as some of the factors, both intrinsic and extrinsic, that affect this diversity. I then discuss the role of bioarchaeology in the exploration of these factors and their role during growth and development, which ultimately affects adult standing height. The chapter includes previous methods used in the estimation of stature and its significance in bioarchaeology, including understanding and controlling for sexual dimorphism. This chapter also explores social structure and the relationship between social complexity, mortuary practice, and expectations for health status. Finally, I discuss some of the current literature on the Chachapoya region and people as well as the two Chachapoya sites used in this study.

Human Variation in Physical Form

The human physical form is affected by environmental and genetic factors alike, but expressions of physical diversity, such as melanin production or stature, are interpreted in biological anthropology as adaptations to climate and natural access to resources (Gangestad and Scheyd, 2005; Larsen, 2010; Lasker, 1969). Many biological adaptations to environment present in human physiology are invisible to the naked eye, such as increased lung capacity and hemoglobin counts in high altitude populations or reduced susceptibility to malaria due to heterozygous sickle cell alleles, but many others are clearly observable (Allison, 1954; Beall, 2013; Gong et al., 2013; Gonzales et al., 2009; Moore et al., 1998). Some of these apparent adaptations include melanin production and hair structure, but one of the most studied variant in human populations is adult morphology, examined through analyses of standing height and limb length proportions (Neave and Shields, 2008; Stock, 2013; Vercellotti et al., 2014). Adult standing height and limb length have become a focus for biological anthropologists due to the ease of data collection from both living and past populations, but unfortunately, few studies address all the major factors that affect stature during the interpretation of their results (Becker et al., 2012; Bogin and Varela-Silva, 2010; Mummert et al., 2011; Neves and Costa, 1998).

Sexual Dimorphism

Sexual dimorphism in humans causes visible changes during puberty that remain into adulthood (Walsh-Haney et al., 1999). The differences between adult males and females can be attributed to variations in both gross morphology and functional morphology, with males being, on average, 7 - 8% larger in size (Byers, 2011). There is observable diversity in sexual dimorphism between regional populations, and some studies have attempted to understand the associated factors (Frayer, 1980; Holden and Mace, 1999; İşcan, 2005; Nettle, 2002; Ruff, 1987; Shine, 1989; Wells, 2012). As with all aspects of morphological differences, behavioral and environmental factors greatly affect sexual dimorphism. This intersection of behavior and biology is studied through biocultural approaches, which account for behavior along with external pressures in human adaptation and evolution (Dufour, 2006; McElroy, 1990). With this approach, studies of sexual dimorphism have demonstrated that physical differences between males and females have been greatly affected by general patterns of cultural behavior as well as gender roles in the division of labor (Frayer, 1980; Holden and Mace, 1999; Ruff, 1987). Sexual dimorphism may also be affected by patterns of sexual selection and preference, but these behaviors are more difficult to discern in the archaeological record (Becker et al., 2012; Gahtan and Mark, 2013; Nettle, 2002). However, studies have also demonstrated that male and female biology react differently to environmental pressures, where in colder climates males create more lean mass and females create more adipose tissue, and environmental pressures seemingly affect males more prominently than females (Ruff, 1987; Ruff, 2002; Wells, 2012).

Factors Affecting Stature

There are five main factors that have been found to affect adult stature regardless of sexual dimorphism. These five factors are genetics, climate, altitude, pathology, and nutrition (Beall, 2013; Bogin and Keep, 1999; Bogin and Varela-Silva, 2010; Vercellotti et al., 2014; Wood et al., 2014). Each of these conditions may affect individuals at different stages of their growth and development which, in turn, manifest variously as differences in their overall adult body size, limb lengths, radial and crural indices, and appendicular morphology when compared to other individuals within the same population. All of these stimuli affect limb length differently and can thus be differentiated in skeletal analyses (Bogin and Varela-Silva, 2010; Bogin et al., 2007; Cámara, 2015; Roberts, 1978; Serrat et al., 2008; Weinstein, 2005; Wood et al., 2014). The results from these studies suggest that the difference between potential height (as provided by genetic inheritance) and actual height (as affected by extrinsic pressures) account for the wide variety of statures observed within relatively isolated geographic populations.

Extrinsic pressures affect individuals during critical phases of growth and development, leading to trade-offs in energy consumption and stunting stature (Bogin et al., 2007; Pomeroy et al., 2012; Schooling et al., 2008a; Schooling et al., 2008b). Of the previously mentioned factors affecting stature, climate and altitude are particularly important to evolutionary studies due to their implications of evolutionary biology. Humans are the only species to be adapted across extremes of climate and altitude and the effects of these varied living conditions create observable differences in humans (Bailey et al., 2007; Weinstein, 2005; West, 2006). Nutrition and pathology, as they relate to stature, have the ability to demonstrate patterns of inequality and disparities in access to resources (Cámara, 2015; Neves and Costa, 1998; Pfeiffer and Harrington, 2011; Vercellotti et al., 2014). Due to the multidimensionality of stature, factors not directly related to research questions in a study must be controlled or the researcher may mistakenly interpret their results (Byers, 1994; Vercellotti et al., 2014).

Genetics and Stature

It is commonly believed that genetic inheritance accounts for a significant portion of achieved adult stature. Although inheritance can account for up to 90% of stature variation, genetic studies have found that as many as 9,500 Single Nucleotide Polymorphisms (SNPs) account for only 29% of stature diversity (Wood et al., 2014; Yang et al., 2010). This suggests that variations in the genome control a very small portion of the diversity observed in stature. The highly complex nature of stature in genetics directly translates to the inability of using ancient DNA to study the divergence of potential and actual height. Studies on the role of the environment on stature have also reduced the importance of genetic inheritance on adult stature (Becker et al., 2012; Bogin and Varela-Silva, 2010; Bogin et al., 2007; Cámara, 2015; Ruff, 2002; Vercellotti et al., 2014; Wolański, 1979).

Effects of Climate on Growth and Development

In studies of human skeletal morphology and evolutionary adaptation, climate is defined as the relative mean ambient temperature for a geographic region (Roberts, 1978; Serrat et al., 2008; Wells, 2012). Since the middle of the 19th century, the effect of climate on body proportions and limb morphology has been described (Allen, 1877; Bergmann, 1847). The first of these descriptions is attributed to Carl Bergmann and has been termed Bergmann’s rule. It states that populations found in colder climates will have larger body mass than those in warmer climates since endothermic animals require a stable body temperature (Bergmann, 1847). Joel Allen expanded the explanation for this rule by adding that differences occur in the ratio between volume and surface area of the body (Allen, 1877). As surface area increases, heat is more easily transferred between the individual and the environment leading to a reduction in heat trapped within the body. The opposite is true for a lower surface area-to-volume ratio, which leads to a reduced loss of internal heat in colder environments. In order for the body to adapt and change the surface area while maintaining the volume, the limbs must increase in length and robusticity must be reduced leading to taller, thinner individuals in warmer environments and shorter, more robust individuals in colder environments (Roberts, 1978; Wells, 2012). A recent study by Serrat et al. (2008) has discovered that cold environments affect growth by reducing the proliferation of chondrocytes. Chondrocytes control the deposition of endochondral bone, but not intramembranous bone, thus affecting long bone diaphyses while maintaining cranial and trunk proportions (Serrat et al., 2008). This can lead to a lower surface area for the individual via reduced limb length, as was predicted by Allen (1877).

Effects of Altitude on Growth and Development

Altitude, climate, and nutritional deficiency are intricately tied, but the one factor affecting individuals at high altitude, defined as environments above 2,500 meters above sea level (m.a.s.l), that does not affect individuals at lower altitudes is hypobaric hypoxia – reduced oxygen in the air due to reduced atmospheric pressure (Beall, 2013). Lifelong residents of these high-altitude regions have developed biological responses to the environment that allow them to thrive with limited oxygen (Beall, 2013). Many of these responses, however, result in what would be considered abnormalities in sea-level populations (Bogin et al., 2007). Research has found that non-residents in these regions are more severely affected by the hypobaric hypoxia than lifelong residents, and this diminishing of the negative effects during adulthood have been explained as adaptations and trade-offs (Bailey et al., 2007; Bogin et al., 2007; Moore et al., 1998; Pomeroy et al., 2012). These adaptations are separated into four categories: cultural, acclimatization, developmental, and genetic (Beall, 2013). All adaptations rely on the need for reduced energy expenditure and reduced energy intake, which in turn affect growth and development (Bailey et al., 2007; Beall, 2013; Moore et al., 1998). The developmental category of adaptations is the locus of affected stature.

Oxygen deprivation and the energy requirements of high-altitude environments affect the growth of individuals *in utero* as well as throughout childhood (Bailey et al., 2007; Beall, 2013; Moore et al., 1998). Specifically, stunted growth (which affects final stature) appears in the lower limbs, and is more pronounced in the tibia (Bailey et al., 2007). Growth and development in a high-altitude environment are affected such that those individuals are generally shorter but present overall longer limbs for their standing height when compared to individuals living at or near sea level (Weinstein, 2005). In the Andes, there are marked differences between mid-altitude and high-altitude Andean groups in the ratio of appendicular length to trunk height (Pomeroy and Stock, 2012; Weinstein, 2005). Compared with relative newcomers, lifelong residents of high-altitude regions present fewer detrimental effects of hypobaric hypoxia (Beall, 2013; Moore et al., 1998). Specifically pertaining to development, these adapted populations exhibit “less intrauterine growth retardation, better neonatal oxygenation, and more complete cardiopulmonary transition”, which directly translate into better oxygenation of growing tissue and a better postpartum outlook for the child (Moore et al., 1998:25). Andean populations, in this case, are considered newcomers, and thus are affected by hypobaric hypoxia (Beall, 2006).

Pathology of Growth and Development

Congenital conditions, those affecting skeletal morphology since birth, are clearly discernible in the long bones, and the two most well-known conditions that stunt growth and produce reduced stature are achondroplasia and pituitary dwarfism. Achondroplasia is a specific form of dysplasia that leads to limited endochondral growth but normal intramembranous bone formation (Ortner, 2003:329; Rodríguez et al., 2012; Sables, 2010; Waters-Rist and Hoogland, 2013). Diagnostic postcranial traits include disproportionate length of bones most pronounced in the femur and humerus and normal diaphyseal diameters and cortical thicknesses with disproportionately wide epiphyses and metaphyses (Rodríguez et al., 2012; Waters-Rist and Hoogland, 2013). Pituitary dwarfism is the result of a deficiency in a growth hormone leading to proportional dwarfism. The skeleton is generally gracile, with thin cortical bone, sparse trabeculae, and a thin layer of bone closing the metaphyseal surface indicating stunted growth and leading to non-union of the epiphyses until possibly much later in life (Aristova et al., 2006; Roberts, 1987). Other pathological conditions during growth and development cause a redirection of resources from growth and development causing stunted growth (Aufderheide and Rodriguez-Martin, 1998; Bush, 1991; Ortner, 2003). These conditions must be addressed as factors affecting growth but do not require direct diagnosis in a population-wide study.

Nutrition Deficiency during Growth and Development

Pathological conditions may also be related to nutritional deficiency. Primary among these diseases due to nutritional stress are rickets and osteomalacia. Rickets and osteomalacia are difficult to discern from each other, but they greatly affect long bone morphology during growth and development (New and Bonjour, 2003; Ortner, 2003:273-280; Ortner and Mays, 1998). They are associated with a vitamin D deficiency. While vitamin D can be synthesized by the body through exposure to the sun (UVB radiation) or acquired through diet, colder regions and those with less sunlight due to increased cloud cover as well as general malnutrition possibly lead to the manifestation of these disorders. The result is brittle appendicular bones, with thin cortexes and sparse trabecular bone (Hoffman and Klein, 2012). Growth is slowed, but the timing of ossifications centers remains within normal expectations, leading to shorter limbs but generally normal development. Subperiosteal bone deposition thickens the diaphysis at the midshaft, which gives the bones a column-like appearance and thus do not exhibit the normal tapering at the midshaft. Lastly, and most diagnostically, the pliability of long bones with rickets often leads to an extreme curvature of the diaphyses including bowed legs and reduced stature; however, this is not always the case (New and Bonjour, 2003; Ortner and Mays, 1998). Most pathological conditions that affect morphology severely can be identified through simple observations; however, not all pathological conditions are so easily diagnosed (especially in fragmentary remains), and some may have been obliterated by the time the individual dies.

Less severe variation in nutrition, specifically iron and zinc deficiencies, will lead to stunted growth (Black et al., 2008; Dietz et al., 1989). These deficiencies manifest most often in the bones of the lower limb with little to no changes in the height/length of the torso (Bogin and Varela-Silva, 2010). Thus, comparisons of torso length to leg length become efficient metrics to discover deficiencies in nutrition between individuals within a population (Bogin and Varela-Silva, 2010; Cámara, 2015).

In modern societies, the nutritional deficiencies are also correlated with socio-economic status and limited access to other resources such as healthcare (Baten and Blum, 2012; Black et al., 2008). Investigations of differences in the diets of pre-historic societies have often revealed inequalities in access to high-value foods, such as meat, which also contain high levels of iron necessary for adequate bone tissue growth (Cheung et al., 2012; Costin and Earle, 1989 ; Curet and Pestle, 2010; Le Huray and Schutkowski, 2005; Pearson et al., 2013; White et al., 1993). These differences are rarely seen within less complex, more egalitarian societies (Dietz et al., 1989). Variations in nourishment that lead to these periods of nutritional and subsequent physiological of stress in individuals, when observed in some defined sub-groups and not others, may suggest differential access to resources and a socially stratified complex society.

Stature and Health

Stature estimates are often used as a proxy for health when creating cross-cultural comparisons (Feldesman and Fountain, 1996; Genovés, 1967; Holliday, 2002; Pfeiffer and Harrington, 2011; Pietrusewsky et al., 1997; Pomeroy and Stock, 2012; Raxter et al., 2006). Some scholars have suggested that health and stature are inextricably linked, and thus support the use of stature as a marker of population health (Baten and Blum, 2012; Cámara, 2015; Larsen, 1995; Pietrusewsky et al., 1997; Williams and Murphy, 2013). Regional and ancestral variations have been extensively studied in regards to stature (Feldesman and Fountain, 1996; Genovés, 1967; Moore et al., 1998; Pomeroy and Stock, 2012; Trotter, 1951), but the simplistic perspective of stature as an indicator of health prevails in diachronic analyses within bioarchaeology (Larsen, 1995; Pietrusewsky et al., 1997; Williams and Murphy, 2013). Stature has also varied widely in human populations since before the Neolithic period (Holliday, 2002; Larsen, 1995; Pinhasi et al., 2011). Therefore, many researchers that have attempted this approach have discovered problems in such an interpretation due to the complexities involved in attaining adult stature (Becker et al., 2012; Gahtan and Mark, 2013; Moore et al., 1998; Pfeiffer and Harrington, 2011). Although multiple studies have used stature as a proxy for health, this relationship appears oversimplified when other factors involved are not controlled, leading to fallacies in the conclusions being drawn.

Bioarchaeology and Human Biological Diversity

American Anthropology is an academic discipline composed of four subfields: archaeology, biological anthropology, socio-cultural anthropology, and linguistics. At the intersection of archaeology and biological anthropology is the discipline of bioarchaeology. This multidisciplinary specialty examines the human past through the recovery of physical human remains and the investigation of their mortuary contexts (Buikstra and Beck, 2006; Walker, 2008a). Researchers examine human biological trends to better understand evolution, adaptation, and overall health in the past (Agarwal, 2012; Brickley and Ives, 2010; Knudson and Stojanowski, 2008). Unfortunately, the term "health" is often too broadly defined, using a modern, Western definition of the term, which includes incorrect assumptions about adaptation and environmental pressures (Temple and Goodman, 2014). One way to mitigate these assumptions is to investigate health as a relative term, using for reference only the local life histories (Roksandic and Armstrong, 2011; Wright and Yoder, 2003). Bioarchaeology, thus, allows researchers to examine the intersection of biology and culture in the human past within a region, but insight is derived from cross-cultural comparisons.

Studies into past human health also suffer from the osteological paradox, which states that the individuals who died from non-traumatic causes cannot be considered healthy (Siek, 2013; Wood et al., 1992). This is also true in cases where no skeletal lesions may be observable, and is often where stature plays a role in health analyses. If an individual suffers stress during growth and development and is shorter than their peers, they thus demonstrate a hidden frailty and are more susceptible to further stress during adulthood (Byers, 1994). Some studies have suggested link between short stature and further stress in adulthood leading to diminished longevity in the past (Amoroso et al., 2014; DeWitte and Hughes-Morey, 2012; Kemkes-Grottenthaler, 2005; Samaras and Elrick, 1999). However, research on modern populations seems to suggest the opposing correlation of shorter men actually living longer, demonstrating the complexity of this subject (Bartke, 2012; He et al., 2014; Kabat et al., 2013; Salaris et al., 2012; Samaras, 2007). Therefore, this research seeks to explore this complex relationship in the skeletal remains of a past population and further add to the literature on the subject.

Stature Estimation and Regional Variation

When it comes to estimating stature from the skeletal remains of past people, two main methods have been used: anatomical approximations and linear regression formulae. Anatomical approximations, such as the Fully technique, are created by taking skeletal measurements of multiple elements including of the cranium, vertebrae, sacrum, femur, tibia, talus, and calcaneus. These metrics are then input into a formula that calculates standing height and accounts for the missing soft tissue. This minimizes the error in approximation by including as many skeletal elements involved in standing height as possible (Fully and Pineau, 1960; Pomeroy and Stock, 2012; Raxter et al., 2006; Raxter et al., 2007). While most researchers agree that anatomical approximation is a more reliable estimate (Ousley, 1995; Pomeroy and Stock, 2012), archaeological remains rarely contain all the necessary elements or completeness of skeletal remains for the use of this method. For this reason, many attempts have been made to create regression formulae for stature estimation using single elements (Béguelin, 2011; Fully and Pineau, 1960; Pomeroy and Stock, 2012; Raxter et al., 2008; Trotter, 1951). However, due to a lack of complete archaeological remains and appropriate reference populations, researchers often misuse the formulae based on populations that, while relatively close in geographical proximity, might not fit the proportionality of the sample group (For a discussion on this misuse see: Feldesman and Fountain, 1996; Fully and Pineau, 1960; Ousley, 1995; Vercellotti et al., 2014).

Linear regression formulae (LRF) are created from a reference population (either modern cadavers or complete archaeological skeletal samples) by estimating the living stature of a number of individuals and correlating the results to the dry skeletal measurements of various long bones in order to create a formula in which to input the maximum length or physiological length metrics of appendicular long bones (e.g., femur, tibia) and obtain a stature estimate (Béguelin, 2011; del Angel and Cisneros, 2004; Genovés, 1967; Pomeroy and Stock, 2012; Trotter and Gleser, 1952). Some regional scholars have used anatomical estimation to create new regression formulae for their specific archaeological populations (for an Andean example see Pomeroy and Stock, 2012). In general in the Andes, researchers have consistently used Genovés (1967), and only recently have adopted a modification to Genovés by del Angel and Cisneros (2004) (both of which reference a cadaver sample of modern native Mesoamericans) (Aufderheide et al., 1993; Benfer Jr, 1990; Klaus and Tam, 2009). None has yet applied the formulae created by Pomeroy and Stock (2012), which was developed using anatomical estimates of archaeological mid-altitude Andean samples.

The differences in body proportions resulting from environmental factors raise the question of appropriate estimation formulae. These distinct proportionalities suggest that stature estimations using linear regression formulae from a geographically distinct population are inappropriate (Katzmarzyk and Leonard, 1998; Tanner, 1987). The reference populations for most regression formulae are not biologically connected to the Chachapoya. Although Pomeroy and Stock (2012) use a mid-altitude Andean sample, Weinstein (2005) demonstrated that low-, mid-, and high-altitude populations have significantly different body proportions.

Estimating Sex from Appendicular Elements

The effects of sexual dimorphism on stature need to be controlled when using stature as a proxy for health (Frayer, 1980; Holden and Mace, 1999; Nettle, 2002; Wells, 2012). When the skeletal remains being studied are commingled, sexing individuals from isolated elements (other than the os coxae) becomes problematic. Since stature demographics for a commingled context are generally calculated from appendicular long bones with no associated cranium or os coxae, sex estimates of isolated elements are confounded (Buikstra and Konigsberg, 1985; Byrd and Adams, 2009). In general, the use of postcranial remains to estimate sex has been unreliable due to major overlap in sizes between the sexes, the use of rough boundaries for metric determination of sex, and inability to account for differences in sexual dimorphism across various regional populations (Bass, 1995; Byers, 2011; Stewart and Kerley, 1979).

Recent studies have tried to mitigate these issues of sex determination from appendicular elements through the use of discriminant analyses. Spradley and Jantz (2011) have suggested that multivariate analyses of long bone metrics may provide estimations of sex with an accuracy of up to 95%. Multivariate analyses are difficult in the field due to the necessity of dedicated software, thus logistic regression formulae to determine sex from isolated long bone metrics is a more manageable solution when the demography of the site must be completed without the aid of such software. This method of logistic regression has proved useful in sex determination of forensic cases using the cranium but has yet to be used with postcranial remains, and due to constraints of reference populations has never been used in this region (Dabbs and Moore-Jansen, 2010; Klales et al., 2012; Walker, 2008b).

Social Complexity via Mortuary Practice in the Past

One insight provided by bioarchaeology is the examination of the effects of social organization and complexity on human biology. Social complexity is a controversial topic in anthropology, however, it is often used to define societies with stratification and inequality among its population (Adams, 2001; deFrance, 2009; Layton, 2003; McGuire, 1983; Pearson et al., 2013). Complexity is often based on unequal control of resources, such as agricultural land and access to trade, which often results in disparities in the distribution of necessary goods, such as food (Knipper et al., 2014; Pearson et al., 2013). As with goods, complexity can also be observed in access to labor or specialists and investment in mortuary behaviors, such as tomb construction (Arriaza et al., 2005; Carmean, 1991; Guengerich, 2014; Kamp, 1998; Tainter, 1978). The construction of highly visible sacred burial spaces can be an indicator of complexity and inequality through the demonstration of control of the landscape of the labor required (Abrams, 1989; Moore, 1996; Parker Pearson and Richards, 1994). Complexity, however, is not only seen hierarchically. A society may also be defined as complex when organized heterarchically, in such a way that cultural identity is important but does not lead to disparities in social capital or access to resources (Crumley, 2008; Levy, 2008; Wailes, 2008).

Mortuary spaces, including their construction, placement of the remains, and grave goods serve as signals of individual social identity or status (Herrera, 2005; Lovell, 1998; Mantha, 2009; Moore, 1996; Parker Pearson and Richards, 1994). Examining complexity in mortuary practice fits into the theory of investment where higher labor costs indicate higher social prestige for those interred (Abrams, 1989; Saxe, 1971; Tainter, 1978). Thus, mortuary practices that require more labor investment (often interpreted as labor and material cost) generally suggest individuals of higher social status.

Cultural Identity

Mortuary practices can convey ideas of cultural association that can be translated into social cohesion and power relationships (Mantha, 2009; Moore, 1996). Burial plays an important role in the maintenance of cultural units in Andean cultures, and it can deliver a message of belonging to the people associated with the practices (Guengerich, 2014; Isbell, 1997). Mortuary buildings and their location are not only symbolic but are a form of creating and maintaining the associations to a particular group. When examining burials, their positioning as well as their relationship to each other can create a sense of identity (Brush, 1977; Parker Pearson and Richards, 1994). The location of the interment may also signal an affiliation or status, with selective access or attempts at maintaining relatives close even after death.

Power and Status

Studying the spatial relationships between the mortuary structures of a specific location can also shed light on stratification and hierarchical relationships of individuals within the local group and increase our understanding of broader social organization (Moore, 1996; Parker Pearson and Richards, 1994). Costs associated with interment and mortuary practice can define the status and power of an individual or group (Abrams, 1989). Along with cost, the location of burials can also convey power and status, with highly visible locations being meant to draw attention (Herrera, 2005). Mortuary practice and space can therefore be representative of the status of the individuals interred.

The Chachapoya Region: History and People

The Chachapoya archaeological culture, in the northeastern Peruvian Andes, is relatively little known, but archaeological interest in the region has grown in the past few years. The cultural occupation of the ancient Chachapoya people is defined geographically by the Marañon River to the north and west and Huallaga River to the east, located on the eastern slopes of the Andes facing the Amazonian basin (Figure 1)(Church and von Hagen, 2008). This high-altitude semi-tropical environment (> 2,500 m.a.s.l.) is described as *Ceja de Selva* or *Selva Alta* (High Jungle), due to its heavy yearly rainfall and extremely steep terrain (Bonavia, 2000; Church and von Hagen, 2008). The Chachapoya region extends around 155,000 km ^{2}, with residential sites located high on the slopes of neighboring mountains. As such, any movement across this landscape would be equivalent for all residents of the area, thus controlling for environmental pressures on the biology of the local population (Bonavia, 2000).

Chachapoya scholars debate the socio-political organization of the region during what is believed to be the peak of cultural development here in the Late Intermediate Period (AD 1000-1470). Archaeological evidence seems to suggest that the Chachapoya had a unified cultural identity only during their conquest and incorporation by the Inca empire ca. AD 1470 (Church and von Hagen, 2008; Nystrom and Toyne, 2014; Schjellerup, 1997). According to the Spanish chroniclers, the Chachapoya were a collective group (single identity) of fierce warriors who repeatedly rebelled against Inca domination (Guengerich, 2015; Nystrom and Toyne, 2014). However, these historic sources do not describe the relationship among the communities in this region before Inca domination. Scholars have more recently collected evidence of a somewhat unified cultural identity for the people living in this region, but more research is required to understand its connection to the wider Andean network (Guengerich, 2015; Nystrom, 2006).

This study will explore two distinct sites in the Chachapoya region: the monumental residential center of Kuelap and the large mortuary complex of La Petaca (Figure 2).

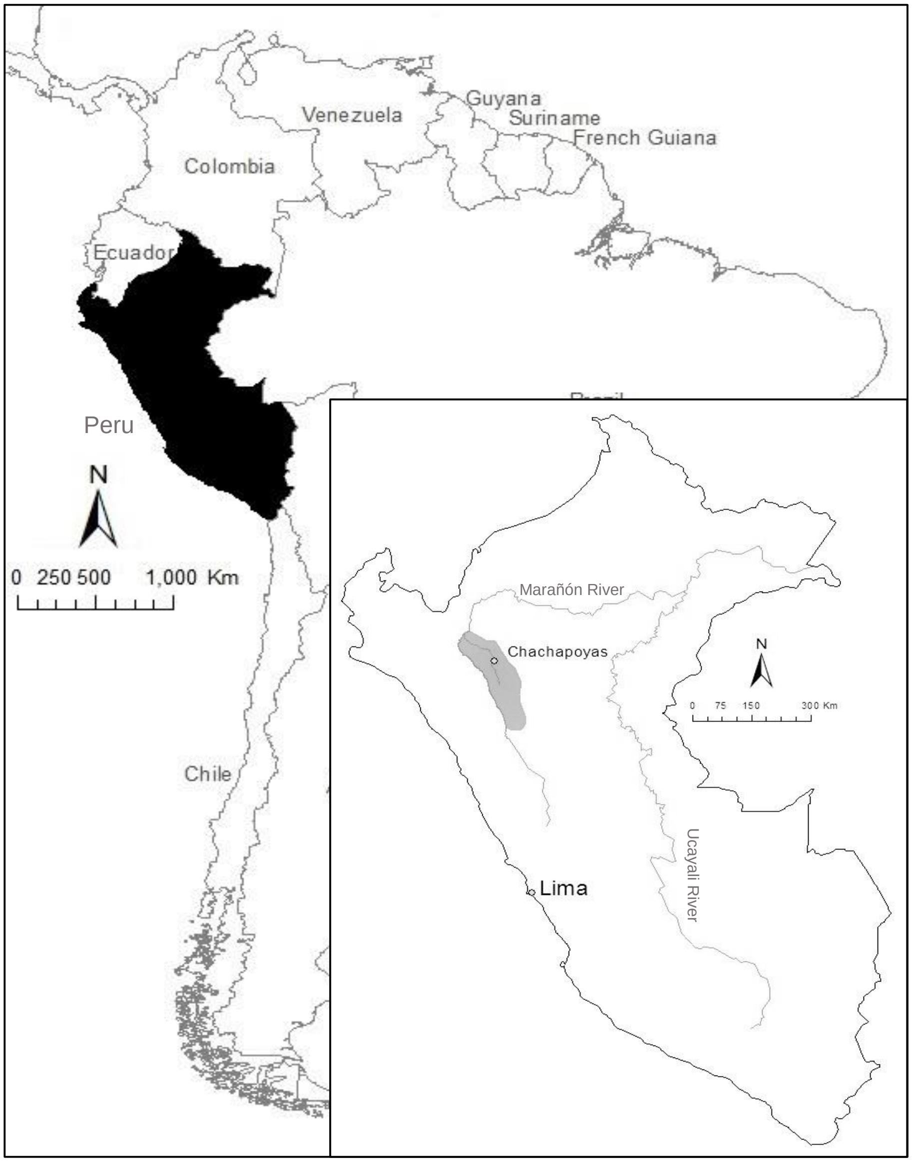

Figure 1: Map demonstrating the location of the Chachapoyas region within modern Peru in relation to other South American nations and major Amazonian drainage systems in that country.

Figure 2: Map demonstrating the location of archaeological sites (red), modern towns (black), and rivers (blue) within the region. The proposed extent of Late Intermediate Period (AD 900 – 1470) Chachapoya cultural influence is shown (green). The two major sites of study, Kuelap and La Petaca are in bold lettering.

Kuelap

The site of Kuelap is a monumental citadel located on a ridge top (3,000 m.a.s.l.) 35 km south of the town of Chachapoyas (Narváez, 1987; Toyne and Narváez, 2014). The site encompasses 4.5 km ^{2}, with over 400 residential structures, with retention walls achieving a maximum constructive height of 20 m (Figure 3), and has been interpreted as an important religious/political site in the ancient Chachapoya region and culture (Church and von Hagen, 2008; Narváez, 1987; Nystrom and Toyne, 2014).

Figure 3: Outer retention wall for the site of Kuelap. Large vertical faces of cut stone have been interpreted by some scholars as evidence of fortification of the site. Immense effort and time were clearly invested in the creation of this site. (Source: JM Toyne)

In addition to the seeming "fortification," the site also contains agricultural land, suggesting that individuals lived continuously at the site. Although it is primarily a residential site, Kuelap exhibits a wide variety of burial practices including a secondary ossuary deposit, interments under house floors, placement in constructive walls, conical collective tombs, individual plaster sarcophagi, and large mausolea (Figure 4) (Ruiz Estrada, 2008; Toyne and Narváez, 2014). This diversity of interment practices may suggest hierarchical or heterarchical social differentiation, but further research is necessary to understand their meaning. A total of 613 well-preserved burials of adults and juveniles have been recovered at the site. This study analyzes adult remains of complete burials with established sex and age estimation, which total 161 individuals, including males (n=107) and females (n=54). All burial types are incorporated into a single sample in order to examine the morphological variation since genetic homogeneity can be assumed and controlled for this site (Nystrom, 2006).

Some scholars argue against interpretations of biological homogeneity and suggest the Chachapoya region could not have been isolated since Chachapoya contact with other distant contemporary sites is evident in the archaeological record (Guengerich, 2015). However, this evidence does not preclude natal philopatry (the tendency for an individual to remain where they are born), and stable isotope studies on oxygen ratios for the site of Kuelap suggest that the individuals buried there were local residents since childhood, with few migrants present at this site (J. Marla Toyne, personal communication).

Figure 4: Images of three different mortuary practices observable at the site of Kuelap. Left to right: Burial pit beneath a house floor; burial niche within a retention/constructive wall; cone shaped burial structure with multiple individuals. (Source: JM Toyne)

La Petaca

Unlike the residential site of Kuelap, the site of La Petaca is an archaeological mortuary complex located 14 km southwest of the modern town of Leymebamba (Figure 2). It is a massive natural rock wall with at least 124 structures over a façade of 12,000 m^2 and an occupation that spans over 600 years (AD 900-1470) (Figure 5) (Gonzalez and Toyne, 2014; Toyne and Anzellini, *in press*). La Petaca is a complex of only mortuary structures, with no identified residential structures within the limits of the site, although various large habitation sites are located nearby (for archaeolgical analyses of one of these residential sites see: Guengerich, 2014).

This site represents the largest Chachapoya mortuary complex studied to date in the region. The architecture across the site is highly varied and includes placement of human remains in collective niches, caverns, and open chamber tombs of varying architectural complexity (Gonzalez and Toyne, 2014; Toyne and Anzellini, *in press*). While La Petaca demonstrates diversity in the elaboration of mortuary spaces, it still contains different elaboration when compared to other Chachapoya mortuary sites, such as Los Pinchudos, which demonstrates intricate design and friezes on the outer walls of the mausolea (Bracamonte, 2002; Morales Gamarra, 2002). This comparison suggests that La Petaca might be internally segregated, represents a different cultural group, or is of overall lower status (Toyne and Anzellini, *in press*). Unfortunately, the site has been heavily looted and the cultural material that may have been at the site is no longer there. This reduces the strength of social interpretations, but the skeletal remains are still relatively well preserved.

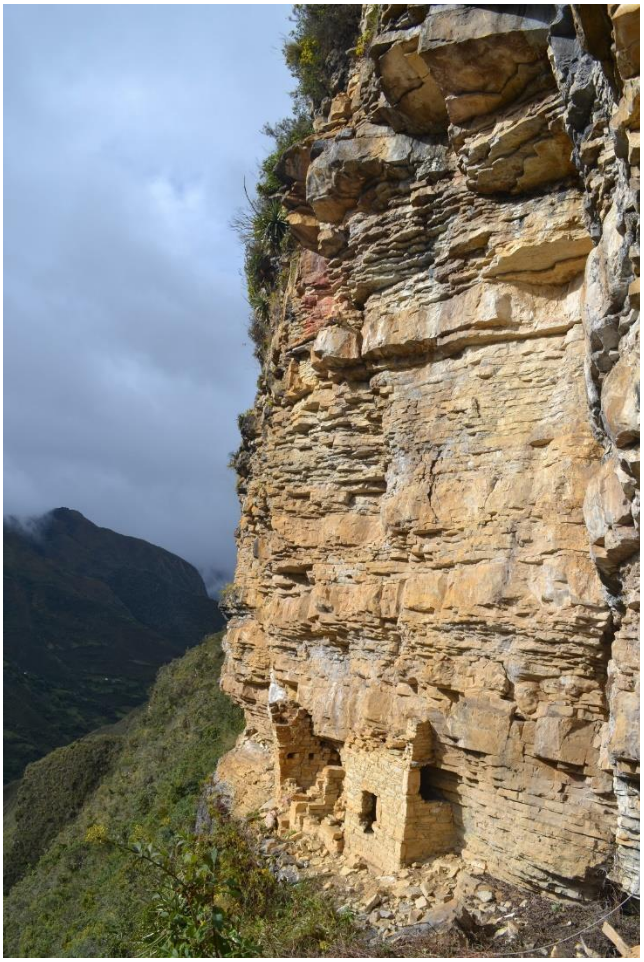

Figure 5: La Petaca mortuary complex is built on a vertical face using various natural ledges and niches to dispose of human remains. The natural spaces and constructed tombs appear to be contemporaneous according to preliminary radiocarbon dates. (Source: JM Toyne)

For the purpose of this research, the commingled remains discovered within the natural caverns and caves were examined together to explore the utility of developing sex based regression models to predict the sex of unknown isolated elements and assist in the creation of a paleodemographic profile of disturbed contexts. The remains from a natural cavern on the Superior sector named CF-01 (AD 1190-1270) represent the largest minimum number of individuals (MNI) (n=55), characterized by fragments of long bones from almost 8,000 skeletal elements (Epstein, 2014). This natural cavern is relatively small and is located in the more easily accessible sector at the site (Figure 6) (Epstein and Toyne, 2016). While the commingling might be the result of looting or animal activity, spatial analyses by Epstein and Toyne (2016) suggest that the remains represent multiple depositional events over an extended period of time. Chronologically, this natural space was being used contemporaneously with the more elaborate and individualized mortuary structures at the site, suggesting that the differences are not due to temporal changes in mortuary practice (Gonzalez and Toyne, 2014; Toyne and Anzellini, *in press*). Age distribution of the remains suggests that CF-01 contains 43 adults and 12 juveniles with a balanced distribution across all age categories. Due to the commingled nature of the remains, sex demographics for this population are based on the cranium and os coxa alone, but they indicate a relatively even distribution of males and females (Table 2). This known demographic profile of a commingled context supplies the perfect sample for the application of additional paleodemographic methods to improve our understanding of the use of this context and the individuals being interred there.

Table 2: Estimated sex distribution of the sample from La Petaca from crania and os coxae recovered from the commingled remains (Adapted from Epstein, 2014).

Element	Males	Females	Indeterminate	% Male	% Female
Crania	7	13	5	28%	52%
Os Coxae	13	14	2	42%	45%

Figure 6: Image demonstrating the commingled nature of the context from La Petaca. Multiple scattered elements are observable within this small mortuary context including long bones, crania, os coxae, and scapulae. (Source: JM Toyne)

Chapter Summary

In this chapter I have discussed human variation in the physical form and the various environmental pressures that lead to these adaptive morphological changes. This chapter explores the debates in the correlation of stature and health as well as the effects of sexual dimorphism and the biocultural factors with which it is associated. I have also presented in detail the factors that may affect stature directly through the environmental suppression of growth, lack of biological resources, or genetic predisposition. I then described the bioarchaeological approach to the exploration of human biological diversity as well as some of the methods that have been previously used in bioarchaeological research to estimate stature, sex, and compare these profiles to understand the biology of past populations. This chapter also discusses theoretical approaches to determining status from mortuary remains, both cultural and biological.

Lastly, I presented the current debates in Chachapoya archaeology, and a brief description of the sites being used in this study. In the following chapter I will outline the materials analyzed as well as the data collection and analytical methods applied to explore the hypotheses. These focus on the examination stature variation in the region, the estimation of stature for a population, and the use of isolated remains to determine sex distributions in commingled contexts.

CHAPTER THREE: MATERIALS AND METHODS

In this chapter, I discuss the samples selected for this study including skeletal collections from the Chachapoya sites of Kuelap and La Petaca followed by published stature data from the Andes for use in comparative analyses. I then explain the procedures for data collection and estimation of missing metric data as well as the calculation of intraobserver and interobserver error. This is followed by a presentation of the method for anatomical stature approximation. Next, I define the tests used in the statistical comparison of variance followed by the creation of a new regression formula and the method for comparing to previously published regression formulae for stature estimation. Subsequently, I explain the procedure for creating a logistic regression formula to estimate sex from isolated remains. Lastly, I will explain the process used to test the validity of the sex estimation method and the application of the previously presented methods to the commingled sample at the site of La Petaca.

Materials

To test the three hypotheses formulated for this study involving variation in stature, stature estimation formulae, and sex estimation from isolated remains, two original samples were collected and compared to three published samples from the Andes. The samples include a collection of complete and mostly complete individuals with estimated sex and age for anatomical stature approximation and collected metrics of individual long bones from remains of estimated sex and age from Kuelap, as well as a set of commingled remains from La Petaca to test the application of the methods developed in this study. The three comparative samples originate from Northern Chile and Southern Argentina representing coastal, mid-altitude, and Patagonian populations.

Kuelap

An estimated total of 613 well-preserved human skeletal remains of adults and juveniles have been recovered from the site of Kuelap. This study analyzed adult skeletal remains of mostly complete individuals (75-100%) that are fairly well preserved with established sex and age estimates, which total 161 individuals, including males (n=107) and females (n=54). Sex for this sample was estimated by Dr. J. Marla Toyne based on morphological differences established by *Standards for Data Collection from Skeletal Remains* (Buikstra and Ubelaker, 1994). All burial types were incorporated into a single sample in order to examine the morphological variation since genetic homogeneity is assumed and controlled for at this site (Toyne, personal communication). However, no skeletal evidence for specific congenital disorders resulting from limited genetic diversity, such as dwarfism, are observable at this site. In order to examine the variation in stature across the Andes, the Fully technique for anatomical stature approximation (from here on known as the Anatomical method) was calculated from collected metrics using the data collection sheet presented in Appendix A.

La Petaca

For the purpose of this research, the commingled remains discovered within a natural cavern at La Petaca were examined together to explore the utility of developing sex based regression models to predict the sex of unknown isolated elements and create a paleodemographic profile of disturbed contexts. The remains from the natural cavern named CF-01 (AD 1190-1270) represent the largest minimum number of individuals (MNI) (n=55), with almost 8,000 isolated elements, and an even distribution of sex estimated from crania and os coxae. The isolated appendicular remains recovered from these commingled contexts include humeri (n=52), femora (n=87), tibiae (n=73), and calcanei (n=20), few of which could be associated as belonging to the same individual. Various metrics that define the morphology of each element were collected from these remains including lengths, articular breadths, and shaft diameters. These remains varied in preservation from excellent and complete to poor and fragmentary. The most common taphonomy present was moisture damage leading to cortical flaking due to the high humidity of the cavern.

Comparative Andean Samples

Most published skeletal analyses in the Andes have omitted stature estimations, and even those which have included such estimations often do not provide the standard deviations of their samples. For this reason, only two published samples are suitable for this comparative study due to the presentation of their data and their application of Anatomical stature estimation: Béguelin (2011); and Pomeroy and Stock (2012). These studies provide samples from a range of geographic regions in the ancient Andes including low-altitude Patagonian populations (<500 m.a.s.l), coastal Argentinian and Chilean populations, and mid-altitude Peruvian and Chilean populations (1,000 – 2,500 m.a.s.l) (Figure 7). They also represent various subsistence strategies as well as a range of periods of occupation from the Late Holocene (ca. 2500 BP) to the Late Horizon (beginning ca. AD 1470) (Table 3).

Béguelin (2011) sampled 36 adult individuals including both males (n = 27) and females (n = 8) from two lowland Patagonian pre-Hispanic sites, Sierra Colorada (SAC) and Chubut, and used the Anatomical method for estimating stature. Descriptive statistics provide a male mean stature of 170.50cm (SD = 4.332) and a female mean stature of 160.84cm (SD = 6.311).

The study by Pomeroy and Stock (2012) consisted of 122 adult individuals collected from six sites across the coastal and mid-altitude regions of Peru and Chile. While the authors approximated adult stature using the Anatomical method for various sites, the only significant sample sizes came from the coastal site of Azapa (n = 27), and the mid-altitude site of San Pedro de Atacama (n = 71), each including both males (n = 16 and n = 39, respectively) and females (n = 11 and n = 32, respectively). The mean male stature for Azapa was 156.75cm (SD = 3.859), with the mean female stature averaging 148.80cm (SD = 3.889). For the site of San Pedro de Atacama, mean male stature was 159.29cm (SD = 5.091) and mean female stature was 149.25cm (SD = 4.728). Sample size, mean stature, and standard deviation for each of these sites are presented in Table 4. These three comparative samples provide a cross-section of the variation encountered in the Andean region.

Table 3: Summary of sites for the samples used in this study including geography, time period of occupation, subsistence strategy, and social structure.

Site	Geography	Time Period	Subsistence	Social Structure
***Kuelap* [1]**	High-altitude Forest	Late Intermediate	Agriculturalist	Chiefdom
***La Petaca* [1]**	High-altitude Forest	Late Intermediate	Agriculturalist	Chiefdom
***Azapa* [2]**	Coastal Desert	Late Intermediate	Agro-pastoralist	Chiefdom
SPA* [2]	Mid-altitude Desert	Early intermediate	Agriculturalist	Egalitarian
SAC* [3]*	Temperate Grasslands	Late Holocene	Hunter-Gatherer	Tribal
***Chubut* [3]**	Temperate Coast	Late Holocene	Hunter-Gatherer	Tribal

* San Pedro de Atacama, ** Sierra Colorada. [1] Church and von Hagen (2008), [2] Pomeroy and Stock (2012), [3] Béguelin (2011).

Table 4: Sample sizes, mean stature and standard deviation of comparative Andean samples.

Site	N	Mean Stature (cm)	SD
***Azapa* [2]**			
Males	16	156.75	3.859
Females	11	148.8	3.889
SPA* [2]			
Males	39	159.29	5.091
Females	32	149.25	4.728
Chubut/SAC* [3]*			
Males	27	170.5	4.332
Females	8	160.84	6.311

* San Pedro de Atacama, ** Sierra Colorada. [1] Church and von Hagen (2008), [2] Pomeroy and Stock (2012), [3] Béguelin (2011): These sites were placed together by the author due to their small sample size

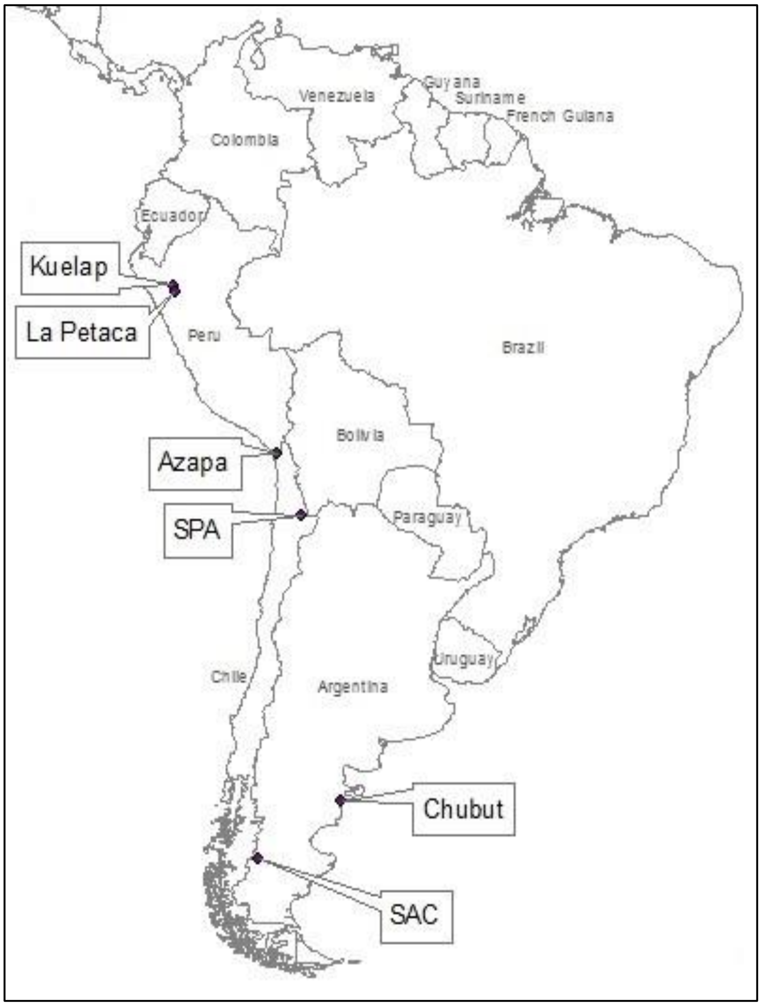

Figure 7: Map of South America depicting the location of the sites used in this study: Kuelap and La Petaca in the Northern Peruvian Highlands, the coastal lowlands of the Azapa valley and mid-altitude site of San Pedro de Atacama (SPA) in northern Chile, and the lowland fertile sites of Chubut and Sierra Colorada (SAC) in southern Argentina.

Data Collection Methods

The data for this research are quantitative and include metrics collected from complete, clean skeletal remains. Standard metric data were collected from appendicular elements (i.e., humerus, femur, tibia, and calcaneus) and recorded using dedicated spreadsheets (Appendices B-

F). Humeral data was used only in the estimation of sex but was not used in stature estimation or comparisons of variance. The metric data include maximum lengths, physiological lengths (e.g., bicondylar length of the femur), proximal articular breadths, distal articular breadths, and midshaft diameters (both anterio-posterior and medio-lateral), and were collected as recommended in the volume *Standards for Data Collection from Human Skeletal Remains* (Figures 8-11) (Buikstra and Ubelaker, 1994). Long bone lengths were collected using an osteometric board while articular breadths, calcaneus length and breadth, and mid-shaft diameters were collected using sliding calipers with a precision of 0.01 mm.

The anatomical estimation of stature from the Kuelap sample through the Anatomical method requires the collection of the following metrics: cranial height (basion to bregma), height of the axis including the dens, height of the anterior vertebral body for C-3 through L-5, anterior height of the first sacral element (S-1), bicondylar length of the femur, maximum length of the tibia from lateral condyle to medial malleolus (condyle-malleolus tibial length), and height of the talus and calcaneus when articulated (Figures 12-14) (Raxter et al., 2006). Cranial height was collected using spreading calipers and all long bone length metrics as well as talus calcaneus height were collected using an osteometric board. Vertebral heights were collected using sliding calipers with a precision of 0.01 mm.

If an individual was missing vertebrae, four or fewer, from the thoracic or cervical spine, methods proposed by Auerbach (2011) to estimate those missing elements were applied. This method allows for the estimation of vertebral height from adjacent elements. When two adjacent elements are missing, the Auerbach (2011) method is applied with iterations of the estimate until no change is observed at 0.001mm. If more than two adjacent elements were missing, that individual's vertebral column height was calculated from the sum of the heights of lumbar vertebrae alone, or was discarded if the lumbar vertebrae were unreliable. These data were collected from the left side elements of the individual unless otherwise noted in the collection sheets (Appendix A). In addition to the metrics explained above, femoral and tibial maximum lengths were also collected from the Kuelap sample of 36 complete individuals to directly correlate Anatomical stature with these metrics.

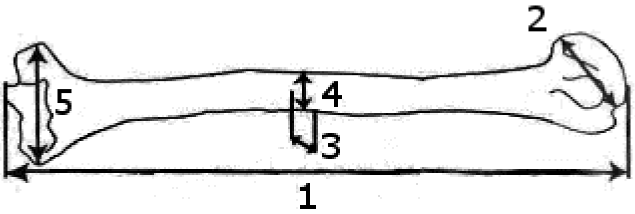

Figure 8: Diagram of left humerus demonstrating the collected metrics (after Buikstra and Ubelaker, 1994). 1) Maximum Length, 2) Humeral Head Diameter, 3) Anterior-posterior Diameter, 4) Medio-lateral Diameter, 5) Distal Articular Breadth.

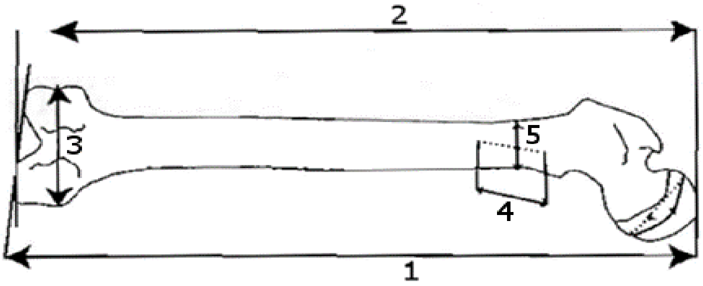

Figure 9: Diagram of left femur demonstrating the collected metrics (after Buikstra and Ubelaker, 1994). 1) Maximum Femoral Length, 2) Bicondylar Length, 3) Distal Articular Breadth, 4) Anterior-posterior Diameter, 5) Medio-lateral Diameter.

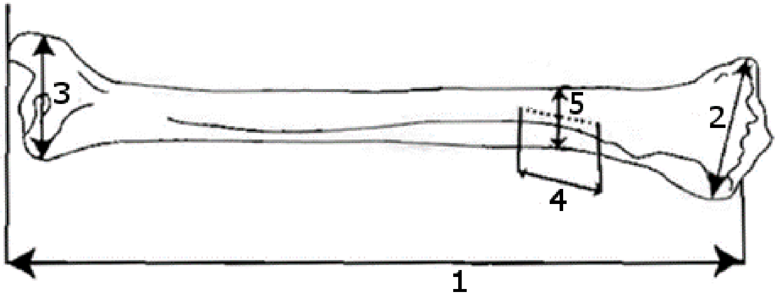

Figure 10: Diagram of a right tibia demonstrating the metrics collected (after Buikstra and Ubelaker, 1994). 1) Condylar-Malleolar Length, 2) Distal Articular Breadth, 3) Tibial Plateau Breadth, 4) Anterior-posterior Diameter, 5) Medio-lateral Diameter.

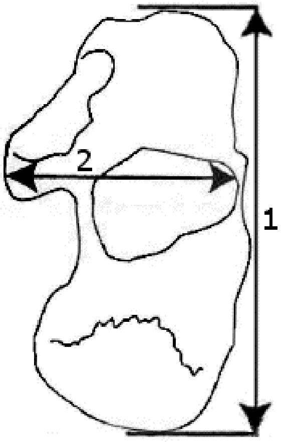

Figure 11: Diagram of right calcaneus demonstrating metrics collected (after Buikstra and Ubelaker, 1994). 1) Maximum Length, 2) Maximum Breadth.

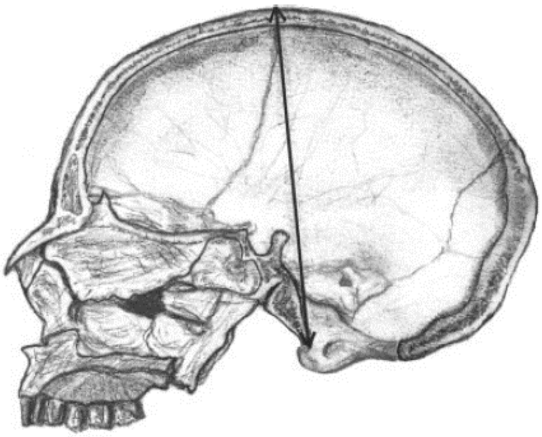

Figure 12: Diagram of cranium demonstrating the collection of cranial height: Basion to Bregma (from Raxter et al., 2006).

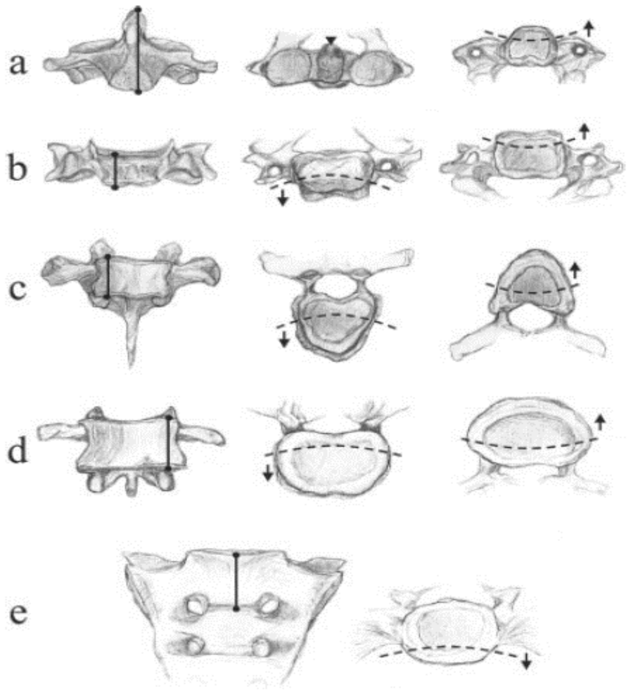

Figure 13: Diagram of vertebrae demonstrating the collection of vertebral body height metrics: a) C2 vertebral height including dens, b) height of cervical vertebrae from the anterior quarter of the body, c) thoracic vertebral height from anterior half of body, d) lumbar vertebral height from anterior portion of body, e) height of S1 segment at promontory and transverse line (from Raxter et al, 2006).

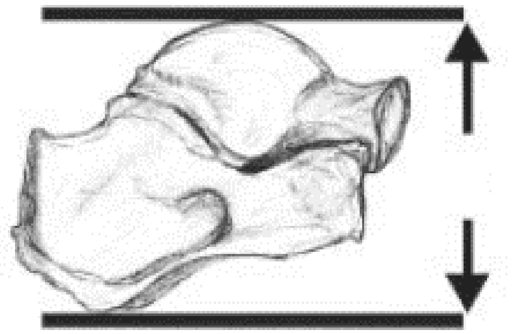

Figure 14: Diagram of right talus and calcaneus demonstrating the measurement of talus-calcaneus height (from Raxter et al., 2006).

Interobserver and Intraobserver Error of Skeletal Metrics

Ten percent of the Kuelap sample metrics were duplicated to examine intraobserver measurement error, and ten percent of the measurements taken by the author were compared with those previously collected by Dr. J. Marla Toyne to assess interobserver error. To test the reliability of the collected metric data, the technical error of measurement (TEM) was calculated (Adão Perini et al., 2005; Lewis, 1999; Ulijaszek and Kerr, 1999). This calculation quantifies the average deviation of measurements collected at two different points by the same individual or by two different individuals. It requires that the two datasets be measured in the same scale and is calculated by the following equation:

$$TEM = \sqrt{\frac{\Sigma D^2}{N}}$$

Where D is the difference between two observations, and N is the total number of observations. These can then be converted into coefficients of reliability (R) that take into account the standard deviation within the sample and provide the correlation between the two sets of measurements.

This coefficient standardizes the comparison by removing the necessity of equivalent scales. The coefficient of reliability is analogous to the Pearson correlation coefficient with an acceptable reliability occurring at values of R above 0.9, calculated by the equation:

$$R = 1 - \left(\frac{(TEM)^2}{(SD)^2}\right)$$

Where SD is the standard deviation of the entire sample.

In this study, the technical error of measurement and coefficient of reliability were calculated for measurements of the cranium, vertebrae, femur, and tibia for intra-observer error, and femur, tibia, and calcaneus lengths were compared to previous collections of metrics from the Kuelap sample to assess interobserver error.

Traditional Linear Regression Formulae

In the Andes, the primary LRF used for stature estimation is the XLF regression from Genovés (1967). In addition to the femoral regression, Genovés (1967) presented LRFs for the tibial length (CLT). These formulae were created from a cadaver population from Mesoamerica that was specified as indigenous descendants. Genovés suggested a subtraction of 2 cm from the final calculation that accounts for the differences between living height and cadaveric height. In addition to this complication, there was an inconsistency in Genovés's calculations of regression formulae, both of which were later corrected by del Angel and Cisneros (2004). Therefore these LRFs are based on a modern population from a region that is geographically distant from the Andes. To resolve this issue, Pomeroy and Stock (2012) used the Anatomical method (Fully) on archaeological samples in the Andes to more accurately estimate ancient stature. The authors of that study collected metrics of skeletal remains from six sites in Chile and Peru (i.e., Mantaro

Valley, Paloma, Chinchorro, Azapa Valley, Pica-8, and San Pedro de Atacama). They then used the collected metrics to create LRFs of the XLF, BLF, and CLT that could be applicable across the Andean region and suggested that, when using individual elements, the BLF regression formula is most appropriate for females and the CLT regression formula is most appropriate for males (Pomeroy and Stock, 2012). All three of these studies assume significant sexual dimorphism and thus create separate regression formulae for males and females. The LRFs tested in this study are presented in Table 5.

Table 5: Linear regression formulae for a single metric of lower appendicular long bones chosen for this study to compare anatomical estimates of stature to regression estimates from various reference populations in the Americas.

Variable	**Sex**	**Genovés (1967)**	**del Angel & Cisneros (2004)**	**Pomeroy & Stock (2012)**
XLF				
	Male	66.379 + (2.26 x XLF)	63.89 + (2.262 x XLF)	44.803 + (2.738 x XLF)
	Female	49.742 + (2.59 x XLF)	47.25 + (2.588 x XLF)	48.340 + (2.593 x XLF)
BLF				
	Male	-	-	47.207 + (2.705 x BLF)
	Female	-	-	49.147 + (2.600 x BLF)
CLT				
	Male	93.752 + (1.96 x CLT)	91.26 + (1.958 x CLT)	53.354 + (2.997 x CLT)
	Female	63.781 + (2.72 x CLT)	61.29 + (2.720 x CLT)	57.748 + (2.800 x CLT)

Calculation of Anatomical Stature

The next step in this analysis is the anatomical estimation of stature using the Fully technique for the sample from Kuelap (Fully and Pineau, 1960; Raxter et al., 2006). The metrics collected for the sample of 36 semi-complete individuals were entered into the revised Fully formula as per Raxter et al. (2006):

$$\textit{Living Stature} = (1.009 \times \textit{Skeletal Height}) - (0.0426 \times \textit{age}) + 12.1$$

Where *Skeletal Height* is the summation of cranial height, vertebral column length, height of the first segment of the sacrum, bicondylar femoral length, condyle-malleolus tibial length, and talocalcaneal height. This formula accounts for missing soft-tissue and changes that occur to the joint spaces as a result of the aging process with a margin of error of ±4.5cm.

Ordinary Least Squares Regression Formula for Stature Estimation

Regression formulae were created correlating anatomically estimated stature from the Kuelap sample to their respective collected metrics of lower appendicular long bones. For the application of previously published regression formulae by del Angel and Cisneros (2004) and Pomeroy and Stock (2012) the maximum lengths were input into the respective equations. Anatomical approximations form the basis for the creation of ordinary least squares (OLS) linear regression formulae with the maximum femoral and condyle-malleolus tibial lengths as individual estimators due to their strong correlation with stature (del Angel and Cisneros, 2004; Genovés, 1967; Pomeroy and Stock, 2012; Raxter et al., 2008; Trotter, 1951; Zakrzewski, 2003). R^2 values were calculated to examine the strength of each regression formula, and only those with a strong R^2 value ($R^2 > 0.7$) were chosen. The creation of these regression formulae completes the comparative sample that consisted of three regression estimates for each lower appendicular long bone and one anatomical estimation.

Logistic Regression for Sex Determination

For this investigation, sexual dimorphism was analyzed for each metric within each element studied using a positive one-tailed t-test to assess the degree of dimorphism present in the Kuelap population with previously estimated sex (Figures 8-11). A one-tailed t-test was chosen due to the expectation of larger males, and provides increased statistical robusticity because the entire alpha of 0.05 null hypothesis rejection region is contained in a single tail rather than divided across two tails (two-tailed analysis). This procedure was followed by the creation of a logistic regression model based on the Kuelap sample to more reliably classify male and female isolated skeletal elements through the application of this formula. Due to the difficulty of dealing with missing data, all cases missing measurements as a result of postmortem damage or fracture were excluded from the logistic regression portion of the study, thus reducing the sample size for each part of the analysis.

Binary logistic regression is a method of predictive modeling particularly suited for dichotomous categorical outcomes such as male and female (Lomax and Hahs-Vaughn, 2013; Martin and Bridgmon, 2012). It analyzes the covariance of a set of independent variables (metrics) and a dichotomous dependent variable (sex). Once the predictive formula has been created, its application provides a log odds ratio value that can be interpreted as a probability that an unknown individual is classified as one or the other of the categories being tested. There are two issues with logistic regression: 1) overfitting and 2) sample sizes.

Over-fitting refers to a model that has categories too narrow to generalize to other samples leading to errors in classification. One way to account for this problem is to use a stepwise regression model, but this method has been found faulty due to differences in how the predictors are selected for each model and it has been shown to significantly increase over-fitting when compared to a simplified logistic regression (Lomax and Hahs-Vaughn, 2013; Rigg and Hankins, 2015). To avoid over-fitting, the predictor variables must be chosen in such a way that variance is maximized but the categories for classification remain the same. While the t-tests used to examine sexual dimorphism may be useful to discover predictors, they are too sensitive in their assessment and provide too many possible predictive variables for modeling. Fortunately, the variances of these predictor values can be calculated through the use of eigenvalues, which are calculated from the scatter matrices within each class and between the classes. Scatter matrices are used instead of covariance matrices since these are samples and not the entire population, thus scatter estimates are more robust than attempts at calculating a population covariance (Dwyer, 1967).

Eigenvalues describe the magnitude of effect that a specific variable has on the variance of the sample relative to the other variables; if an eigenvalue is small, that variable has a weak effect, while if the eigenvalue is large, that variable has a strong effect (Jolliffe, 2002). The magnitude of the effect of each variable can then be presented as a percentage of total variance, providing a simpler presentation of the effect of each variable. In this study, the collected metrics of each element were analyzed in this manner and a maximum of four predictive variables were chosen for modeling.

Another possible issue of logistic regression is the preference of balanced sample sizes. This issue is easily addressed by the application of the Prior Correction to the intercept of the predictive model (King and Zeng, 2001). Once the independent variables have been chosen and the correction has been applied to the intercept, the program is run to provide coefficients for each of the independent variables and predict the odds that a given set of parameters are classified as a one or a zero (male and female, respectively). These coefficients create a model of the form:

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n$$

Where y is the log odds value (Logit), β_0 is the intercept, β_n is a predictive coefficient, and n is the number of independent variables chosen for the model. A positive Logit value suggests a classification into category one, while a negative Logit suggests a classification into category zero. The validity of this method was tested self-referentially, meaning that the model was applied to the reference sample and a percentage of correct classification was calculated with a threshold of 95% considered acceptable. Unfortunately, the limited known sample from Kuelap does not allow for testing of the method on an independent sample, which would yield a more robust test for validity. However, the high threshold compensates for the issues associated with self-referential testing and minimizes the probability of adopting an invalid model.

Analytical Methods

In order to investigate the hypotheses formulated in this research, these data were statistically analyzed to discover significant relationships, compare variances, and create predictive models. The Python programming language in conjunction with the SciPy modules (http://www.scipy.org) were used to create a statistical package that read the data, implemented the necessary procedures, and produced plots and tables of the results. The implementation of each step of the analysis is described in detail in the following sections.

Examination of Stature Estimates

Previous research has suggested that creating new (OLS) regression formulae from Anatomical estimations is viable for simplifying future estimations within the reference populations (Béguelin, 2011; Pomeroy and Stock, 2012; Raxter et al., 2008). However, the precision of these regression formulae, when compared to the anatomical estimation method, has rarely been tested (cf. Pomeroy and Stock, 2012), and has never been tested for the Chachapoya. These formulae will be evaluated by their accuracy when their estimates for the Kuelap sample are compared to the Anatomical method estimates while taking into account the standard error of the estimate (SEE) for each regression presented. This method of evaluating stature estimation formulae is commonly applied in the creation of regression formulae from Anatomical estimates (see: Béguelin, 2011; Pomeroy and Stock, 2012).

Examination of Variances

Very few scholars publish complete datasets of metrics from each skeletal element examined; however, all scholars studying stature publish their methods of estimation and the descriptive statistics of their sample (e.g., sample size, mean, standard deviation). Although complete datasets are ideal, these descriptive statistics are the only necessary values for statistical comparisons of variance (SD^2). All of the Andean datasets used the Anatomical method to estimate stature, thus their comparison to the Kuelap sample was consistent in the method of stature estimation. The Bartlett's test was implemented to compare the variances of these various distributions. Normality assumptions for these data were reasonable due to the consistent normality of stature distributions (Pomeroy and Stock, 2012).

The Bartlett's test is an omnibus test that compares the variances of various samples to determine statistical differences with the null hypothesis being that the sample variances are equivalent, while the alternative hypothesis is that at least one sample variance is significantly different. For this test a level of significance of five percent was chosen ($\alpha = 0.05$) and no assumptions about directionality were made (two-tailed test). The equation is:

$$\chi^2 = \frac{(N-k)\ln S_p^2 - \sum_{i=1}^{k}(n_i-1)\ln S_i^2}{1+\frac{1}{3(k-1)}\left(\sum_{i=1}^{k}\left(\frac{1}{n_i-1}\right)-\frac{1}{N-k}\right)}$$

Where $N = \sum_{i=1}^{k} n_i$ and $S_p^2 = \frac{1}{N-k}\sum_{i=1}^{k}(n_i - 1)S_i^2$ and is the pooled estimate for the variance.

Significant differences were then tested with a pairwise F-test to discern which groups were responsible for the result. The α-value was corrected using a Šidák correction to compensate for Type I errors, providing an $\alpha = 0.017$ (Šidák, 1967).

Application of Logistic and Stature Regression to Commingled Sample

Once the methods were created and tested, they were applied to the commingled remains at the site of La Petaca, which consisted of isolated appendicular elements of unknown sex. The application of sex and stature estimation methods provides the paleodemographic profile of the commingled remains and permitted an opportunity to compare the interments from La Petaca to those from Kuelap to understand the biological differences and similarities between these two disparate mortuary spaces. Descriptive statistics were calculated for these applications, and their plausibility was examined through detailed comparison of the paleodemography of both sites as well as a previously defined paleodemographic profile of the context (Epstein, 2014).

Chapter Summary

In this chapter, I have presented the samples used in this study including semi-complete remains used for anatomical estimation, the isolated long bones of known sex and age, and the commingled remains used for the verification of the methods. I have also presented the broader Andean samples that will be used for interregional comparisons. I explained the methods used to gather the osteometric data for these various samples, and the process to create anatomical approximations of stature using the revised Fully technique. I then proceeded to discuss the various tests used to verify reliability of the collected data and the significance of the differences in variation, the deviation of regression formulae for stature estimation, as well as the process for creating a logistic regression classification of sex and testing the accuracy of that method. Lastly, I explained the application of these methods to the sample of commingled remains to assess the paleodemography of this context and compare the results with the individual burials from Kuelap. The following chapter, Chapter Four, will present the results of the application of these methods to the samples provided.

CHAPTER FOUR: RESULTS

In this chapter, I present the results from each of the analyses examining the samples from Kuelap, La Petaca, and the comparison of Andean samples. First, I present the reliability of the collected metric data by calculating technical error of measurement for both intraobserver and interobserver error. I then describe the results of the anatomical estimations followed by the creation of regression formulae from the anatomical estimates and a comparison with the previously published regression formulae. Subsequently, the comparisons of variance between the newly created estimates and the comparative Andean samples are presented. The results from the logistic regression procedure are then explored including their test of reliability. Finally, the procedures presented in this chapter are applied to the data from La Petaca.

Intraobserver and Interobserver Error

The measurements examined for reliability include the cranial height, vertebral body heights, long bone lengths, and talus-calcaneus height. These were investigated separately in each of those categories due to highly different means and standard deviations for each measurement. All intraobserver comparisons yielded consistent and reliable results with *R* values above 0.9, which suggest an almost perfect replication of measurements (Table 6).

Interobserver error was examined using long bone maximum lengths for the femur and tibia, as well as calcaneus length data collected by myself and JMT. A random selection of 10% of my original data was compared to a random selection of JMT data. All interobserver comparisons yielded reliable results with *R* values above 0.8, suggesting a strong correlation between the measurements (Table 6).

Table 6: Results from tests of reliability including sample size, technical error of measurement (TEM) values, standard deviations, and R coefficients of reliability for interobserver and intraobserver error.

Comparison and Metric	**N**	**TEM**	**SD**	***R***
Intraobserver				
Cranium	8	0.25	2.759	0.992
Vertebrae	192	0.38	5.897	0.995
Femur (Max Length)	8	1.2	30.075	0.998
Femur (Bicondylar)	8	1.15	30.469	0.999
Tibia (CLT)	8	1.17	29.461	0.998
Talus-Calcaneus	8	1.25	6.102	0.958
Calcaneus Length	8	0.4	6.588	0.996
Calcaneus Breadth	8	0.17	3.202	0.997
Interobserver				
Femur	8	8.33	20.339	0.832
Tibia	8	7.28	18.681	0.848
Calcaneus	8	1.95	4.912	0.843

Traditional Linear Regression Estimates for Kuelap

The traditional LRF were applied to a sample of 36 adult individuals from the site of Kuelap that included both males (n = 19) and females (n = 17) (Table 7). Of these formulae, the Genovés (1967) XLF estimates were the tallest at 162.1 cm for males and 152.9 cm for females. The Pomeroy and Stock (2012) CLT estimates, on the other hand, were the shortest at 157.0 cm for males and 147.4 cm for females. These LRF result in mean stature estimates that vary up to 5.1 cm for males and 5.5 cm for females when applied to the same population.

Table 7: Summary table of stature estimates of Kuelap sample femora and tibiae using traditional linear regression estimates by Genovés (1967), del Angel and Cisneros (2004), and Pomeroy and Stock (2012)

Method	**Males**		**Females**	
	Mean (cm)	***SD***	***Mean (cm)***	***SD***
Genoves XLF	162.1	3.645	152.9	3.701
Genoves CLT	161.5	2.878	150.8	3.307
del Angel & Cisneros XLF	159.7	3.648	150.3	3.699
del Angel & Cisneros CLT	159.0	2.875	148.4	3.307
Pomeroy & Stock XLF	160.8	4.416	151.6	3.706
Pomeroy & Stock BLF	160.8	4.334	151.6	3.815
Pomeroy & Stock CLT	157.0	4.401	147.4	3.404

Anatomical Stature Estimation from Kuelap Skeletal Remains

Anatomical stature estimates were also calculated from the Kuelap sample of 36 adult individuals (Appendix G). This number was reduced from 161 for this method since individuals that did not include a cranium, most lumbar vertebrae (three or more), sacrum, or were missing both elements of the leg were removed from the sample due to the inability to estimate those elements. The age of each individual was estimated as a range, a mean, and a category. Significantly more individuals were categorized as middle-aged adults (MA; n = 21) than young adults (YA; n = 12) or older adults (OA; n = 3), but this distribution is expected. No individual less than 75% complete was accepted for this study, and most individuals were 90%-100% complete, with 16 at 100%, 11 at 90%, and only nine in the 75% category. For individuals missing one of the necessary long bone lengths, an OLS regression was performed and applied (as per Auerbach, 2011), which resulted in the following two formulae:

$$CLT = 0.874 * BLF - 23.17$$

and

$$BLF = 1.031 * CLT + 64.12$$

Where CLT is condylar-malleolar tibial length and BLF is bicondylar length of the femur. After anatomical estimation, the mean sample height was 153.40 cm (SD = 7.205), with mean male height of 158.30 cm (SD = 5.307), and mean female height of 147.90 cm (SD = 4.665).

OLS Regression from Kuelap Skeletal Remains: Self-Regression

OLS regression was performed for each long bone separately. Elements with two measurements of length (i.e., femur, calcaneus) were also analyzed using multiple regression (MR). All regression formulae, with the exception of the calcaneus, resulted in adjusted R^2 values above 0.8, suggesting reliable approximations. These formulae were created using the complete sample, instead of separating males and females, because doing so would have reduced the sample sizes to non-significant levels. Resulting functions and their standard error are presented in Table 8.

Table 8: Linear regression formulae for stature estimation derived from the Kuelap data including their respective Standard Error of Estimate (SEE).

Variable	Function	SEE
XLF	18.524 + (0.328 x XLF)	2.962
BLF	18.559 + (0.331 x BLF)	2.819
XLF + BLF	19.005 + (0.122 x XLF) + (0.207 x BLF)	2.979
CLT	35.821 + (0.353 x CLT)	3.117
XLC	70.275 + (1.160 x XLC)	4.551
MBC	72.746 + (2.005 x MBC)	5.136
XLC + MBC	56.626 + (0.830 x XLC) + (0.926 x MBC)	4.340

Comparative Examination of Stature: Regression Formulae

Results of the comparison suggest that tibial regressions are more precise overall and that the more distant reference populations provide much less reliable estimates when compared to the anatomical method. Figure 15 compares the mean estimate for each of the regression formulae to the anatomically estimated stature for the Kuelap sample.

Anatomical v. Genovés (1967)

Regression formulae for both maximum femoral length (XLF) and condylar-malleolar length of the tibia (CLT) as provided by Genovés (1967), on average, overestimated both male and female stature by 3-5 cm when compared to the anatomical stature estimate. Of these, the CLT regression was approximately 3 cm greater than the anatomical stature for both males and females, but was still more accurate than the XLF regression, which was above the stature estimates an average of 3.8 cm for males and 4.9 cm for females. Even accounting for the subtraction of 2 cm suggested by Genovés (1967) all regression formulae overestimate by a minimum of 0.9 cm.

Anatomical v. del Angel and Cisneros (2004)

The adjustments to Genovés (1967) made by del Angel and Cisneros (2004) were more precise for both the XLF and CLT regressions. Adjusted regressions consistently overestimated the Kuelap sample, anywhere from 0.4 cm to 2.4 cm above the anatomical estimate. XLF regression for males was 1.4 cm above the Anatomical estimate, while for females it was about 2.4 cm above the Anatomical estimate. On the other hand, CLT regression for males was 0.7 cm above the Anatomical estimate, while for females it was only 0.4 cm above.

Anatomical v. Pomeroy and Stock (2012)

Pomeroy and Stock (2012) provided regression formulae for XLF, CLT, and bicondylar length of the femur (BLF). Femoral regressions (XLF and BLF) were between 2.5 cm and 3.7 cm above the anatomical estimate for males and females, with male estimates for both being 2.5 cm above anatomical estimates, and female estimates being 3.7 cm and 3.6 cm above anatomical estimates for XLF and BLF respectively. The CLT regression was more precise than the femoral regressions but was still 1.3cm and 0.5cm below anatomical estimates for males and females respectively.

Anatomical v. Self-Regression

Self-regression formulae were more precise but still contained some deviations from the anatomical estimates. Femoral regressions (i.e., XLF, BLF, and their multiple regression) were anywhere from 0.9 cm below anatomical estimates to 1.2 cm above. BLF regression was the most precise of these with a male error of 0.8 cm below and a female error of 0.9 cm above anatomical estimates. The CLT regression, proved somewhat more precise with a male error of 0.4 cm below and a female error of 0.8 cm above the anatomical estimates. The most precise of the self-regression formulae was the maximum calcaneal length (XLC) regression with an error of just 0.4 cm below the anatomical estimate for males and 0.4 cm above the anatomical estimate for females. The maximum calcaneal breadth (MBC) regression was quite imprecise with a mean error of 2.2 cm below anatomical for males and 2.6 cm above anatomical for females. The calcaneal multiple regression (MR) was slightly better than the MBC regression, but not better than the XLC, suggesting that the MR in this case is irrelevant. See Figure 15 for a visual comparison of the average error for each method.

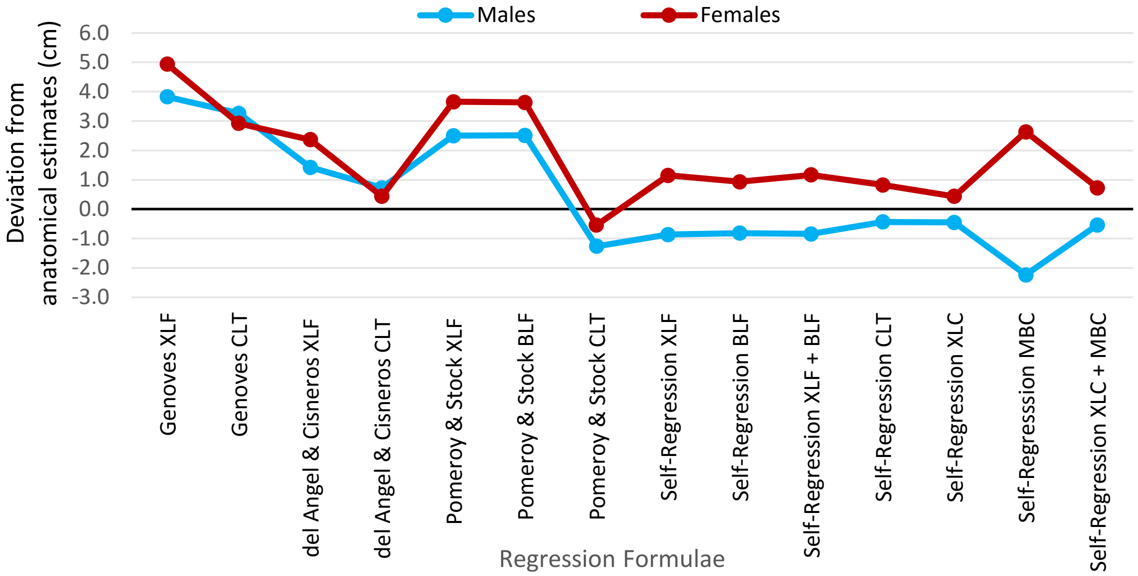

Figure 15: Comparison between the mean anatomical estimate of stature and each of the regression estimates of stature using formulae from Genovéz (1967), del Angel and Cisneros (2004), Pomeroy and Stock (2012), and the OLS regressions conducted in this study. Bolded zero line represents the mean anatomical estimate.

Comparative Examination of Stature: Variance

Examinations of variance among the broader Andean samples using the Bartlett's test resulted in no significant difference discovered for either males (χ^2 = 2.4057, *P* =0.493) or females (χ^2 = 2.0823, *P* =0.556) (Table 9). Due to the possibility of confounding factors (e.g., consistently large variances, unbalanced samples sizes), a Hartley's F-test was then conducted between the data from Kuelap and each comparative sample. The α-value of 0.05 was adjusted accordingly with a Bonferroni correction to 0.017. Again, no difference in the variance of stature was significant when comparing Kuelap to any other sample (Table 10). Comparisons for males and females are visually represented through box plots in Figure 16 and Figure 17.

Table 9: Comparison of sample size, mean stature, standard deviation, and range for males and females from Kuelap and the comparative Andean samples. Statures measured in centimeters

Sample	N	Anatomical Mean Stature	SD	Max-Min (Range)
Kuelap				
Male	19	158.3	5.307	145.35-168.52 (23.2)
Female	17	147.9	4.665	141.02-158.05 (17.0)
Patagonian				
Male	27	170.5	4.332	161.11-177.27 (16.16)
Female	8	160.84	6.311	150.57-170.23 (19.66)
Coastal				
Male	16	156.75	3.859	149.35-163.06 (13.71)
Female	11	148.8	3.889	142.54-157.69 (15.15)
Mid-altitude				
Male	39	159.29	5.091	146.37-170.31 (23.94)
Female	32	149.25	4.728	136.61-160.11 (23.50)

Table 10: Result of Hartley's F-test for all comparisons between Kuelap and the Andean comparative samples accounting for sexual dimorphism.

Compared Samples	F	*P*
Kuelap v. Patagonian		
Males	1.500795	0.832
Females	0.546395	0.150
Kuelap v. Coastal		
Males	1.891249	0.891
Females	1.438889	0.716
Kuelap v. Mid-altitude		
Males	1.086656	0.600
Females	0.973528	0.494

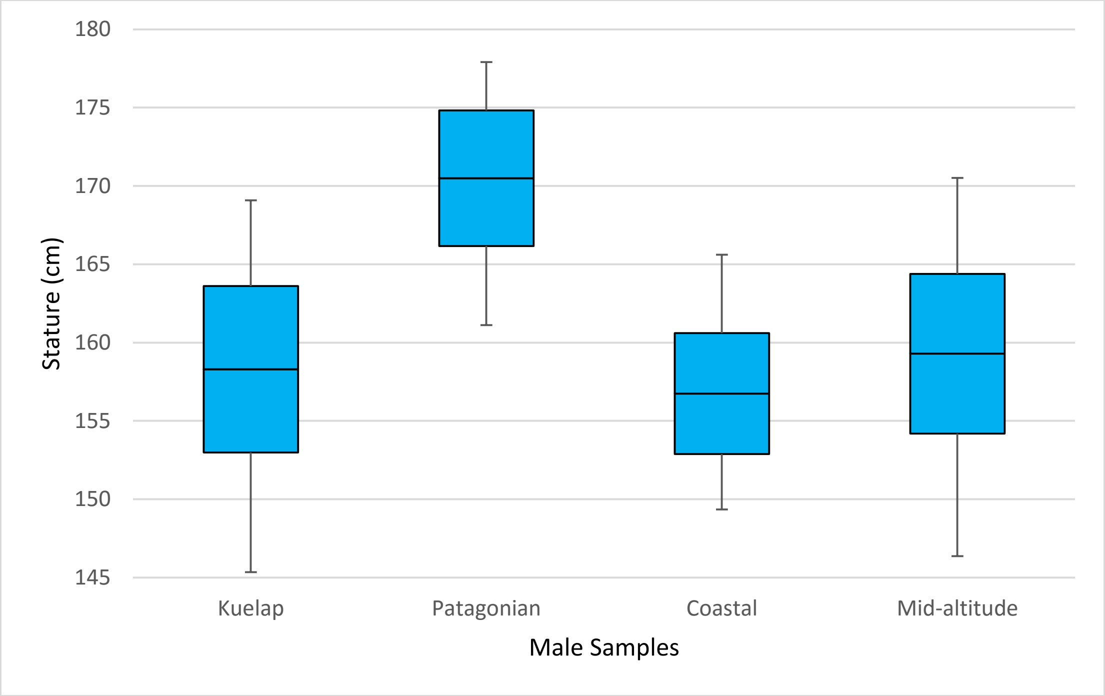

Figure 16: Box plots of stature distributions for males from Kuelap and the comparative Andean samples.

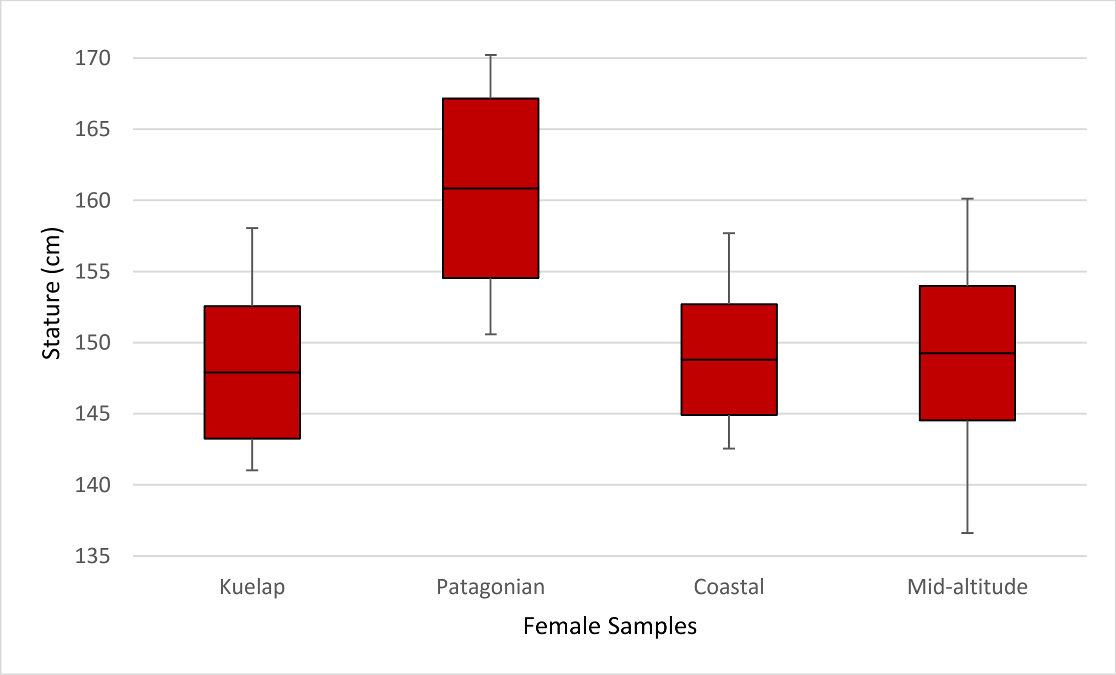

Figure 17: Box plots of stature distributions for females from Kuelap and the comparative Andean samples.

Logistic Regression for Sex Determination

Each element from the Kuelap sample was analyzed independently, dropping all cases with missing data to avoid confounding factors. This reduced the total number of observations for each element but maintained significant sample sizes: 124 humeri (83 males, 41 females), 108 femora (76 males, 32 females), 123 tibiae (80 males, 43 females), and 46 calcanei (30 males, 16 females). Summary data of individual metrics are provided in Table 11.

Table 11: Summary data of male and female individual metrics for each of the elements examined in this study from the Kuelap sample. All data collected in millimeters.

Value	**XLH**	**HHD**	**DBH**	**XLF**	**BLF**	**FHD**	**FDB**	**CLT**	**TPB**	**DTB**	**XLC**
Males											
Mean	302.4	43.4	44	421.8	424.3	44.5	72.3	352.4	72.4	29.7	75
Std Dev	12.23	2.29	2.69	14.91	15.48	1.82	3.69	16.66	3.02	4.37	4.79
Max	338	48.6	56.7	458	461	50	81	388	80.2	53	84.2
Min	273	36.47	35.57	385	387	40.59	61.46	312	65.79	24.49	43.5
Range	65	12.1	21.1	73	74	9.4	19.5	76	14.4	28.5	40.7
Females											
Mean	279.6	38.6	39.5	388.9	385.1	40.1	64.3	318.8	65.2	26.1	66.9
Std Dev	14.68	2.12	2.32	16.24	57.07	1.75	3.45	14.21	2.13	3.72	4.61
Max	334.5	44.1	46.3	425	421	43.3	71.7	347	70	45	73.8
Min	254	32.72	35.13	351	37.5	36.37	55.39	289	60.36	21.88	42
Range	80.5	11.4	11.2	74	383.5	6.9	16.3	58	9.6	23.1	31.8

Sexual Dimorphism

In order to create a balanced testing design for sexual dimorphism to avoid skewing the results, the number of males in the Kuelap sample was reduced through random selection so that males (n = 63) and females (n = 59) had similar sample sizes for all elements and metrics. This random selection was accomplished through the use of a random number generator in Excel and the systematic removal of each case associated with that number. The sample sizes are not equivalent since missing data fluctuates the number of cases for each metric, and this maintains a balanced experimental design. Independent samples t-tests for each individual metric resulted in significant sexual dimorphism ($P < 0.001$), suggesting that a logistic regression is appropriate for these data (Table 12). A post-hoc analysis of power using a Cohen's *d* demonstrated that all tests had large effect sizes ($d > 0.8$). For example of graphical discrimination of sex using the humerus' metrics see Figure 18.

Table 12: Summary table of results from examination of sexual dimorphism through *t*-tests for each metric (some metrics, such as AP and ML diameters were excluded due to reduced sample size). Effect size was measured using a Cohen's *d* test.

Metric	***t***	***P***	***d***
XLH	8.165	< 0.001	1.641
HHD	10.200	< 0.001	2.071
DHB	9.074	< 0.001	1.797
XLF	10.247	< 0.001	2.029
FHD	11.999	< 0.001	2.353
FDB	9.192	< 0.001	1.982
CLT	12.319	< 0.001	2.360
TPB	13.232	< 0.001	2.535
DTB	4.704	< 0.001	0.901
XLC	9.444	< 0.001	1.918

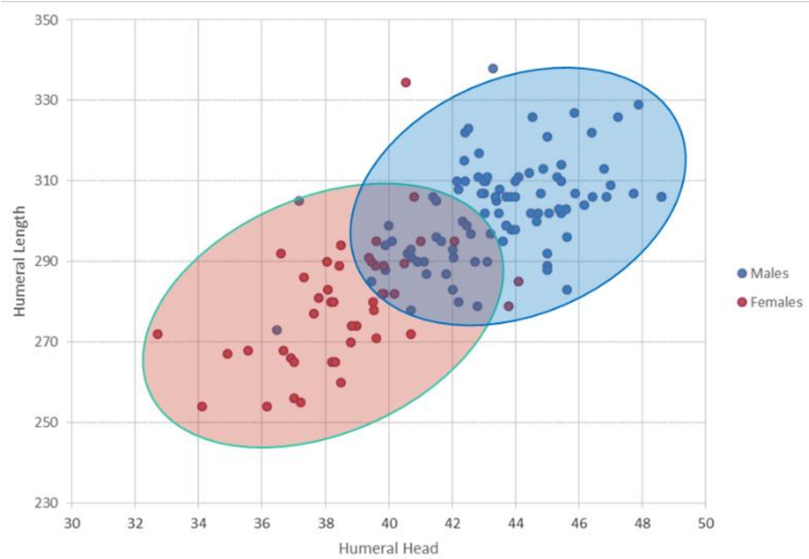

Figure 18: Graph of correlation between humeral maximum length, humeral head diameter, and sex. Ellipsoids represent groupings of males and females, but outliers and overlap are observable in these data.

Reduction of Variables

Eigenvalue results suggested all variance could be attributed to a single independent variable for each skeletal element (Table 13). As a result, all eigenvalues with an order of magnitude of 10^{-17} or below were rejected to reduce the number of variables for the humerus and femur to three and for the tibia to two. The calcaneus only includes two variables, thus this step was unnecessary. A preliminary logistic regression was performed testing the independent variables pairwise until all coefficients were significant for each regression. Two instances for the humerus resulted in significant coefficients, with each regression including two independent variables. The femur and tibia resulted in a single instance of significant coefficients for each with a single independent variable. While a single variable may not provide the most reliable predictions, multiple non-significant variables would have caused similar concerns.

Table 13: Eigenvalues for each variable metric and the percentage of effect each variable has on the variance within the sample for each of the elements examined.

Variables	Eigenvalues	Percent Variance
Humerus		
Length	2.22E-16	0.00%
Head	1.20626	99.99%
Breadth	1.61E-16	0.00%
AP Diameter	2.18E-17	0.00%
ML Diameter	4.67E-17	0.00%
Femur		
Maximum Length	2.96E-01	99.99%
Bicondylar Length	7.26E-15	0.00%
Head	6.80E-16	0.00%
Breadth	6.80E-17	0.00%
AP Diameter	3.34E-17	0.00%
ML Diameter	1.29E-18	0.00%
Tibia		
Condylar-Malleolar	3.79E-01	99.99%
Plateau	3.55E-16	0.00%
Breadth	5.42E-17	0.00%
AP Diameter	2.45E-18	0.00%
ML Diameter	3.09E-18	0.00%
Calcaneus		
Length	1.39E-17	0.00%
Breadth	1.10E-01	99.99%

Logistic Regression

All regression analyses were convergent and demonstrated significant p-values ($P < 0.05$) for all coefficients (Appendix D). Humeral logistic regression analyses were run on 124 observations with a pseudo-R^2 of 0.5347 for the regression utilizing maximum length and head diameter in mm and a pseudo-R^2 of 0.482 for the regression utilizing maximum length and distal breadth in mm. The regression analysis for the femur included 108 observations with a pseudo-R^2 of 0.1373 for a regression with only the maximum femoral length (XLF). Tibial analysis included 123 observations with a pseudo-R^2 of 0.2191 for a regression with only condylar-malleolar length (CLT). Regression analysis of the calcaneus was convergent, but the coefficients were never significant at the α-level of 0.05, thus, this dataset cannot be used to create a logistic regression from calcaneal metrics. Binary logistic regression formulae are presented in Table 14.

Table 14: Logistic Regression formulae for the estimation of sex from humeral, femoral, and tibial metrics.

Variable	N	Function
XLH + HHD	124	(0.0686 x XLH) + (0.6964 x HHD) - 47.8265
XLH + DBH	124	(0.0799 x XLH) + (0.4289 x DBH) - 40.4205
XLF	108	(0.0464 x XLF) - 17.9984
CLT	123	(0.0628 x CLT) - 20.2113

Analysis of Reliability

Reliability tests of the logistic regression formulae were conducted self-referentially on the Kuelap dataset. All predictor formulae demonstrated an accuracy above 80%, with overall and male accuracy above the 90% threshold (Table 15). The humeral XLH and HHD logistic regression proved most accurate for males and overall, both of which were above 90%. The femur XLF logistic regression was the best for estimating females at around 88% accuracy. The tibia CLT logistic regression, although least accurate, was most consistent with around 83% accuracy for both males and females as well as overall.

Table 15: Comparison of each logistic regression formula for the estimation of sex including number of correctly predicted elements, incorrectly predicted elements, and percent accuracy.

Prediction	**Correctly Predicted**	**Incorrectly Predicted**	**Accuracy**
Humerus (XLH +HHD)			
Males	87	7	92.6%
Females	38	6	86.4%
Overall	125	13	90.6%
Humerus (XLH + DBH)			
Males	84	11	88.4%
Females	33	7	82.5%
Overall	117	18	86.7%
Femur (XLF)			
Males	107	22	82.9%
Females	31	4	88.6%
Overall	138	26	84.1%
Tibia (CLT)			
Males	94	18	83.9%
Females	35	7	83.3%
Overall	129	25	83.8%

La Petaca Paleodemography: Estimations of Sex and Stature

The procedures delineated above for estimating paleodemographic profiles from isolated remains were applied to the commingled remains at La Petaca (Figure 19). Due to missing data, total number of observations had to be reduced for each of the elements: humeri (n = 19), femur (n = 27), tibia (n = 30), and calcaneus (n = 20). Summary statistics for each of these elements are presented in Appendix E. In order to compare the mean statures for males and females between Kuelap and La Petaca, sex estimation regressions were applied before stature regression.

Figure 19: Image demonstrating the range in femoral morphology observable at La Petaca. The top-most element is a juvenile, but the three femora below the juvenile are adults. These large differences may cause confusion for researchers prior to metric data collection. (Source: JM Toyne)

Sex Estimation

Results from applying the logistic regression formulae suggest a consistent distribution of males and females for each element. Both logistic regression formulae using the humerus estimate nine males, while the regression using humeral head estimates ten females and the humeral breadth regression estimates nine females. For the femur, the regression formulae estimates 14 males and 13 females, while the tibial regression estimates 16 males and 14 females. These results suggest a relatively even distribution of males and females in this sample, which is corroborated by the estimates created using crania (7 males, 13 females) and os coxae (13 males, 14 females). Sex distributions estimated using logistic regression for each element are presented in Table 16.

Table 16: Estimated sex distribution of the commingled sample from La Petaca using logistic regression of appendicular elements.

Element	Males	Females	% Male	% Female
Humerus (*XLH + HHD*)	9	10	47%	53%
Humerus (*XLH +DBH*)	9	9	50%	50%
Femur (*XLF*)	14	13	52%	48%
Tibia (*CLT*)	16	14	53%	47%

Stature Approximation

Unfortunately, bicondylar femoral length was not collected for the commingled remains at La Petaca, but all other necessary data are present (Appendix F). Stature was approximated using the OLS regression (Self-Regression) created in this study. Average stature from the femoral data for males was 153.4 cm (SD = 4.591, n = 14) and for females was 139.2 cm (SD = 3.851, n = 13). Tibial regression provided a mean male stature of 156.7 cm (SD = 4.957, n = 16) and a mean female stature of 142.9 cm (SD = 4.239, n = 14). For the calcaneal metrics, only maximum length was used, which estimated a mean stature of 150.6 cm (SD = 5.463, n = 20). Males and females could not be distinguished with the calcaneus, so the stature estimates remained un-sexed. Although slight differences were present, all mean values were within their respective standard errors of each other, and their standard deviations were consistent among them.

Chapter Summary

In this chapter I presented the analytical results of this study. Beginning with the reliability of the collected data, I also described the results of the traditional LRF and anatomical estimations of stature. I then presented the results of the statistical analyses of variance followed by the results of the OLS regression. The results of the comparison between stature estimation formulae were also presented and discussed. The results from the reduction of values, the logistic regression for sex estimation, and its reliability have also been explained. This chapter concludes with the application of the previously explained methods to the commingled remains recovered from La Petaca. In the following chapter, the significance of these results will be discussed as they apply to human biology, bioarchaeological interpretations, and the future use of these methods in the Chachapoyas region.

CHAPTER FIVE: DISCUSSION

In this chapter I explore the significance of the results for each of the methods tested as they relate to skeletal morphology and biological variation in the Chachapoya region and culture. I begin with a discussion on the comparisons of variance, regression formulae, and anatomical stature in the Andes and an analysis of the regression formulae used in stature estimation. Following is an analysis of the results of sexual dimorphism testing and sex determinations, their application in the Chachapoyas region, and what these results suggest for future studies of sexual dimorphism and commingled remains. I then discuss the application of these methods to assess the paleodemography of a commingled sample from La Petaca. A necessary review of the methods and their effectiveness is presented and the possibility of their future application to samples in the region as well as outside of it. A discussion of the implications of these results for the study of stress, stature, and health follows, presenting a generalized analysis. Lastly, I consider the implications of these results for our understanding of stature, burial practices, and social complexity in the Chachapoyas region.

Variance, Regression, and Anatomical Stature

Although differences in mean stature and standard deviation are observable among the various Andean samples, the differences fail to reach statistical significance. The ranges for all of these samples were also similar to each other as well as to the expected ranges for modern populations, within 24-27 cm (WHO, 2007). These results suggest that interregional variance is not marked in the Andes, and thus environmental and cultural patterns are not significant contributors to morphological diversity within the broader region. This lack of significant differences might suggest that intra-regional variation in stature is not affected by environmental pressures and variable access to resources; however, it does not suggest that all of these societies had equal levels of social complexity. A range of around 20 cm for all populations without significant changes through time or subsistence patterns suggests a biological imperative that might be the result of natural selection. This wide variability allows genetic flexibility in a population so that when shorter statures are more beneficial, a group can naturally reduce its mean stature. This is not a conscious pattern, since previous research has suggested that sexual selection has very little to do with adult stature (Becker et al., 2012); however, greater diversity is naturally selected due to its correlation with biological fitness (Movsesian et al., 2014; Reed and Frankham, 2003; Scliar, 2012).

Regression formulae appear to be highly dependent on regional limb proportions, but only for broader geographical regions, rather than culturally defined regions. It is clear that the regression formulae created based on Mesoamerican samples (Genovés, 1967) is the least accurate, and those that take into account mid- and high-altitude populations are more accurate for the Kuelap sample (Pomeroy and Stock, 2012). Similarly, the tibial length metrics (CLT) provide the best stature approximations for all reference populations. This is possibly due to the fact that the tibia is more susceptible to environmental pressures during growth and development than other long bones, thus reflecting stature more precisely. Surprisingly, the femur did not provide the most accurate stature approximations, which is contrary to assumptions made by bioarchaeologists (Genovés, 1967; Pomeroy and Stock, 2012). The reason for this result is unclear, but one possibility might be the consistency of proximal limb elements and their resistance to change under environmental pressure (Bleuze et al., 2014; Bogin and Varela-Silva, 2010; Pomeroy et al., 2012).

The Anatomical stature approximations using the Fully technique are perhaps too cumbersome and require too many preserved skeletal elements to apply in all situations. When remains are complete, forensic investigations might benefit from this methodology, but bioarchaeological studies examine too many individuals that are generally poorly preserved for the number and completeness of elements required for this method. Archaeological samples frequently suffer from missing and broken elements, especially the vertebrae, cranium, sacrum, and calcaneus, which are all necessary for anatomical stature approximation and many of which are difficult or impossible to estimate due to population genetics and sample differences (Auerbach, 2011). Of the 613 individuals available from Kuelap for this study, only 36 were viable for anatomical approximations, and of those, approximations of certain elements were still necessary through the application of within-sample linear regressions and self-referential recursive estimations. Therefore, regression formulae using a single element are better suited for bioarchaeological studies since they provide various elements which might be preserved individually. Figure 20 provides a diagram for use with differing examples of the completeness of remains recovered in bioarchaeological samples and the appropriate stature estimation method for each case as suggested in this study.

Unfortunately, the results from this analysis and the lack of accuracy for many of the regression formulae for stature estimation also underline the necessity for population specific regression formulae. The stature estimation formulae presented by Genovés (1967) are commonly used in Andean stature and bioarchaeological studies (Gaither et al., 2008; Pezo-Lanfranco and Eggers, 2013; Toyne and Narváez, 2014), but most often these metric data are gathered and remain unpublished. Recently, more scholars have focused on the importance of stature in bioarchaeology, and from those studies, new regression formulae have been created for some South American populations (Béguelin, 2011; Pomeroy and Stock, 2012; Vercellotti et al., 2014). The results from these various forays into stature estimations suggest that population specific regression formulae are more accurate and more reliable than formulae created from different groups in the same continent. However, the current investigation has demonstrated that generalized population regressions are acceptable if the geographic region is limited, since it is clear that the Pomeroy and Stock (2012) tibial formulae are as precise as every other regression formula created within the Kuelap sample (Figure 15). Due to the inability to preemptively test which of the regression formulae is best suited for each sample, the most viable option is to use either a population specific formula or estimate stature from multiple skeletal elements.

The results from the precision analysis for the calcaneus regression formulae created in this study were surprising. Although not regularly considered an important metric for stature, and thus ignored in most stature studies, there appears to be a strong, positive correlation between calcaneus length and stature. Although a multiple regression of calcaneus maximum length and calcaneus breadth yielded less precise results than other metrics, they still remained well within the precision of the other formulae. While this correlation might simply be an artifact of the sample, it is clear that in bioarchaeological analyses of the Chachapoya, the calcaneus may be useful for stature estimation. Its application in other regions must be studied further in order to understand the significance of this correlation.

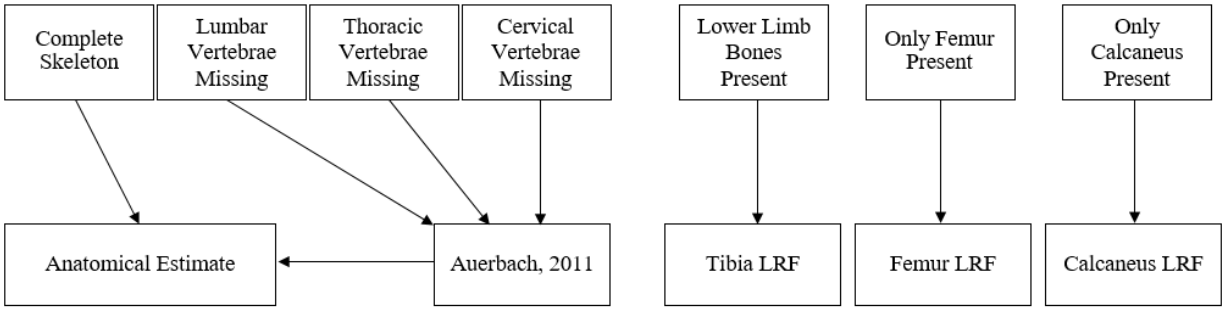

Figure 20: Summary diagram for choice of stature estimation methods providing examples and the appropriate estimation method for each case. Note: the cranium alone cannot be used to estimate stature.

Sexual Dimorphism and Determination

The sexual dimorphism evident at the site of Kuelap is statistically significant (Table 12), and anatomical stature estimates demonstrate that, on average, the difference in height between males and females is approximately 7%, which is well within the expected human average (Holden and Mace, 1999; Ruff, 1987; Wells, 2012). Traditionally, sexual dimorphism has been treated as significant in stature estimations, thus requiring separate regressions for males and females. While some regression formulae, such as that by Pomeroy and Stock (2012) utilizing the tibia, were highly precise (if not entirely accurate), the regression formulae created in this study were non-gendered and still remained as precise as most of the previously published gendered formulae when accounting for standard error. This is not the result of a reduced sexual dimorphism in the Kuelap sample, since the stature of the comparative Andean samples all fall within the expected 5% to 7% dimorphism (Holden and Mace, 1999; Ruff, 1987; Wells, 2012).

Although differences between male and female appendicular measurements were statistically significant in all cases, most metrics were not useful in the discrimination of sex using logistic regression, even if they were significantly dimorphic. These results suggest that although mean differences in morphology may exist between males and females, there is significant overlap in the general morphology of skeletal elements. This overlap reduced the possibility of multiple discriminant analysis using logistic regression, and instead resulted in the application of univariate analysis for some skeletal elements, which was surprisingly successful. The high percentages of accurate sex determination from isolated remains (between 82.5% and 92.6%) supports the conclusions of Spradley and Jantz (2011) with regard to the utility of postcranial metrics in sex estimation, demonstrating the applicability of these methods to various populations.

The multivariate logistic regressions of the humeral metrics provided the highest rates of accuracy in sex determination, up to 93% when compared to the lower limb metrics. Based on previous research on observed sex differences in skeletal morphology, these observations might suggest that the upper limb morphology reflects gendered activity patterns in the Chachapoya region in addition to biological differences (Holden and Mace, 1999; Ruff, 1987; Ruff, 2008; Shine, 1989). Conversely, the similarities in lower limb proportions may also suggest that environmental pressures of traversing this difficult terrain affect males and females in similar ways. Previous research has suggested that the lower limbs are more likely to be affected by environmental pressures (Bailey et al., 2007; Bogin et al., 2007; Cámara, 2015; Vercellotti et al., 2014). The results of this study support this interpretation and provide a possible interpretation of sex-based differences and similarities within the Chachapoya culture. The successful application of this logistic regression for sex estimation (Table 14) produces data from commingled remains, which is valuable in these often ignored contexts where these data may not be taken and such information otherwise be lost.

Paleodemography of La Petaca

Results from the analysis of the paleodemographic profile of commingled remains at La Petaca suggest a group that is evenly distributed between males and females with a stature that is slightly shorter than those for the Kuelap sample (Appendices F and G). The demographic profile from sex estimation is corroborated by the pelvic and cranial analyses of the remains, which suggest a balanced distribution of males and females (Table 2). The use of postcranial remains, however, provide further support due to the larger sample sizes when compared to pelvic and cranial remains.

As for stature, the commingled remains of La Petaca appear to be observably shorter than those in Kuelap for both males and females. The range and standard deviations, however, are almost equivalent, and no marked outliers are observable for either of the samples. Observed shorter average stature may suggest a lower status, where the individuals at La Petaca are of lower socio-economic status than the individuals interred at Kuelap. However, a shorter stature might also suggest an isolated biological group belonging to a different cultural community. The measures of spread (standard deviation and range) are also similar to those of the comparative Andean samples, suggesting no visible difference in the variation of the commingled remains. Greater sample sizes and stature estimates from isolated remains allow researchers to answer questions previously unattainable from commingled remains. When applied to the sample from La Petaca, these methods have proven valuable and viable for use in other commingled contexts around Chachapoyas. They also show promise for their application in contexts outside of the region, but careful examination of their accuracy for other regions must be examined before they can be applied confidently.

Review of Methods for Stature Estimation and Sex Determination

The methods of stature estimation and sex determination created in this study have proved useful in their application to the study of the remains recovered from La Petaca. Stature estimation formulae that are not sex specific allow for the stature estimation of isolated remains in commingled contexts without the need for sex determination. Although the sex estimation method using logistic regression was successful, the application of an estimate on an assumption of correct sex determination would compound possible errors. However, the low impact of sexual dimorphism on regression estimates for stature suggests that such errors may be avoided. The previously published regression formulae created from Andean samples (Pomeroy and Stock, 2012) were precise and accurate enough for the anatomically estimated stature to fall within their standard margin of error. This suggests that those formulae are still useful for estimating stature in this region. It is also clear, however, that regression formulae created with reference populations from an entirely different region, such as Mesoamerica (del Angel and Cisneros, 2004; Genovés, 1967), are inaccurate for the examination of stature in the Andes.

The simplicity of application and interpretation of logistic regression formulae, and the accuracy of over 80% in determining sex make this method a useful tool for bioarchaeological analyses. One problem that is often cited in the study of commingled remains is the lack of a true paleodemography due to the reduced number of elements that may determine sex (Byrd and Adams, 2009; Varas and Leiva, 2012). This logistic regression is as precise as utilizing the cranium alone, thus it may be applied with some confidence in bioarchaeological studies (Byers, 2011; Spradley and Jantz, 2011; Walker, 2008b). Unfortunately, this method is not precise enough to be applied in a forensic context since consistent determinations of sex above 90% are necessary (Byers, 2011).

Both of the previously discussed methods of stature estimation and sex determination were easily and effectively applied to the commingled remains of La Petaca on each of the isolated appendicular elements. Using the stature estimation regression, the remains at La Petaca appear to be of shorter individuals than those recovered from Kuelap. The logistic regression for sex determination could not investigate all of the recovered remains, but provided a broader sample to estimate the sex profile of the context (Table 16). These methods cannot be used individually, but their application alongside other methods of skeletal analysis and sex determination (i.e., using crania and os coxa) used in commingled contexts improves the accuracy of the analyses in such situations by providing further lines of evidence.

Implications for Extrinsic Stress on Stature

Nutrition and pathological stress are often interpreted as the primary extrinsic mechanisms leading to reduced standing height. Investigations of morphological differences associated with nutritional deficiencies have discovered patterns of reduced limb lengths with longer torsos (Bogin and Varela-Silva, 2010; Schooling et al. 2008). However, research on high-altitude populations has demonstrated that these changes may also be associated with climate and recent migrations into high-altitude regions (Weinstein, 2005). Therefore, these factors must also be controlled when investigating differential stature and social complexity.

Research by Weinstein (2005) and Pomeroy and Stock (2012) have suggested that brachial and crural indices tend to be significantly different between low-altitude, mid-altitude, and high-altitude populations. As a group increases their residential altitude, the distal appendicular bones become shorter compared to the proximal bones. Thus, tibiae are affected more significantly than femora, and will provide more reliable metrics in stature estimation if proper regression formulae are applied. However, the effects of altitude and climate on adult standing height are further complicated when populations reside in low-altitude, warm, but arid environments.

The populations at high and mid-altitude (Kuelap and SPA respectively) may have greater environmental stress than the Patagonian population (Chubut and SAC), but it is also clear that the Coastal population (Azapa) were observably shorter on average. However, these differences are minute compared to their intraregional variation (Table 4). Their variances are not significantly different from each other, suggesting either a similarity in the distribution of resources within each group, a resistance to change from mild nutritional differences, or a stable range of genetic diversity. Differences in subsistence strategy, temporal trends, and environmental pressures may also hold the key to understanding these observable differences.

The comparative samples examined in this study present a variety of subsistence strategies and social organizations including Late Holocene (ca. 2500 BP) hunter-gatherers from Patagonia, Early Intermediate Period (AD 200 – 600) egalitarian agriculturalists in the mountains, a Late Intermediate Period agro-pastoral society from coastal Chile, and a Late Intermediate Period (AD 900 – 1470) chiefdom-level agricultural society from high-altitude sub-tropical forests in Chachapoyas (Table 3) (Béguelin, 2011; Costa, 1988; Pomeroy and Stock, 2012; Schjellerup, 2008; Sutter, 2005). This variety in social structure and subsistence strategy provides an adequate basis for the investigation of the effect of socio-political complexity on mean and range of stature. Furthermore, the diversity in climates and geographies (i.e., mountain, coastal, plains) also provide a comparative benchmark for investigations of the effects of climates on stature. Unfortunately, genetic diversity is more difficult to control in the Americas than commonly thought (Cui et al., 2013; Kemp and Schurr, 2010), but the slight variation present between these vastly distant groups and the marginal effect of genetics on adult stature provide this control (Roseman and Auerbach, 2015; Ward et al., 1991; Wells and Stock, 2011; Wood et al., 2014; Yang et al., 2010).

The results of this study indicate that there are no substantial differences in the range of variation of stature across the Andes, and the differences in mean stature between groups is only slight. Using the "stature as a proxy for health" model, the diversity of subsistence strategies, time periods, and climates should result in significant differences between these groups. However, these results lend further support to the criticisms of this oversimplified approach. The observable differences in mean stature across these various groups can be interpreted with context. The coastal population of Azapa, a Late Intermediate Period agro-pastoralist chiefdom, is the shortest of the groups. The Andean coast is well known as an extremely arid place, and this appears to be the only environmental difference between this sample and the Chachapoya sample, suggesting that aridity directly affects stature, possibly through reduced access to dietary resources. The mid-altitude sample (SPA) and the Kuelap sample are similar, as expected, demonstrating that moderate differences in altitude (about 1000m) in a steep and rugged environment does not significantly affect average stature or range in variation. The Patagonian sample appears to be an outlier among these groups having the tallest individuals for both males and females. Multiple factors could be contributing to their height. One of these factors is the altitude. The Patagonian sample was recovered from a site near sea level, thus no hypoxic pressures are present in this group as would be for the mid- and high-altitude groups. When compared to the other sea-level Coastal group, the Patagonians are observably much taller, but they also originate in temperate grasslands rather than a harsh desert environment (Pendall et al., 2001). However, a temporal trend appears to be present as well, with the much earlier Patagonian sample being taller, and the more recent samples having become shorter. This temporal trend is also evident when comparing Formative Period populations to Late Intermediate Period populations from the Andean coastal region (Pezo-Lanfranco and Eggers, 2013). This trend must be evaluated in more detail within a region while controlling for environmental, cultural, and subsistence differences. Clearly, stature is too complex to be used as a single interregional index for health. Comparisons in height between groups that differ temporally, culturally, environmentally, and genetically yield no significant results. However, within each region and culture, many of these factors can be controlled, and some interpretations are possible from the intersection of stature and material culture.

Implications for Chachapoya Society and Health

The results from the comparison of various Andean groups rejects the magnitude of the effect that altitude has on skeletal morphology. These results also suggest that the Chachapoya were quite similar in standing height to other highland groups. No outliers were present in either of the Chachapoyas samples, and there was no clear evidence of major pathological conditions affecting stature, such as dwarfism or rickets. The more pressing question, then, is of the social complexity of the Chachapoya groups, and the possibility of an existing heterarchical or hierarchical social organization in pre-Inca Chachapoyas. While this question is difficult to answer when analyzing the remains of a single sample, it can be addressed by a comparison of the commingled remains of La Petaca to the individualized burials of Kuelap. Issues associated with interregional comparison are mitigated when examining the stature of samples within the same region since various factors, such as altitude and climate, can be controlled.

The generally shorter stature of the commingled individuals from La Petaca may be the result of a variety of factors, but one possibility may be that of social differentiation. The remains at Kuelap were afforded burials that were more easily accessible and within a major site for the region. Those at La Petaca were commingled in a small cavern that may have accumulated remains over time (Epstein and Toyne, 2016). While it may be the imposition of cultural beliefs to assert that commingled remains are afforded lesser status, the "effort" required in the disposal of the remains must be addressed since it can provide insight into power dynamics (Arhem, 1998; Binford, 1971; Brown, 1971; Moore, 1996; Parker Pearson and Richards, 1994). Thus, the effort required in placing remains within a natural opening near the most accessible portion of a difficult-to-access site is still less than that required to place individuals within a constructive wall or underneath housing structures within a residential center. Commingling also suggests a diminished sense of the individual, whereas individualized burials preserve the individual in death. This might suggest that individuals in the commingled cave were of lower social status and, thus, may have had a reduced access to resources. This reduced social prestige of the individuals is represented by their more expedient, low-cost burial (Kamp, 1998; Moore, 1996). However, the possibility of these remains being placed in this context as a way of maintaining cultural cohesion must also be addressed, which would suggest instead a heterarchical organization and not one of social elites and non-elites.

The differences in stature between these two sites are different for each sex as well. Males recovered from la Petaca are an average of 5 cm shorter than those from Kuelap, while females from La Petaca are an average of 8 cm shorter than those from Kuelap (Appendices F and G). This might suggest further differentiation between females than males within this culture since male stature is more susceptible to environmental changes, but the females demonstrate the more noticeable differences (Cámara, 2015; Ruff, 1987; Wells, 2012). All the results from this study have underlined the differences between males and females in the Chachapoya, but as has been previously stated, the dimorphism is around 7%, well within the expected range. At La Petaca, the sexual dimorphism is closer to 10%, much higher than expected, and the highest of all Andean samples. Further research at other sites is necessary, but this might suggest a gender hierarchy that might have been mitigated by the significance of Kuelap (if the individuals interred there, lived there). If the individuals interred at Kuelap, did not live there, then it might suggest that that the individuals that found their final resting place within its walls might have been of higher status, and thus were insulated from gendered inequalities.

The Chachapoya culture has been argued to be a series of chiefdoms that shared ceramic styles, cultural beliefs, and language, and the results of this study provide further support for this interpretation (Espinoza Soriano, 1967; Guengerich, 2015; Schjellerup, 2008). While no major morphological or stature outliers have been recovered archaeologically, the differences in burial treatment appear to be correlated with differences in stature across samples, suggesting that some individuals had greater access to resources during life as well as death. While there are no obvious elites and non-elites, the results from this study suggest a clear difference in the region where individuals might have been differentiated in status as well as gender, although the possibility of a heterarchical organization must still be investigated (Brown, 1971; Dolfini, 2006; Kamp, 1998). Such an organization might demonstrate health disparities with some groups having greater social capital and access to resources without explicit control over political or social decisions.

Chapter Summary

In this chapter, I discussed the results from this study. Beginning with an examination of the methods created, I explored the significance of the results from variance comparisons, regression estimate comparisons, and their application to commingled samples. I also examined the results of logistic regression for sex determination from isolated elements, and explained the significance of sexual dimorphism, consequences of these results in the creation of stature regression formulae. I then discussed the efficacy of these methods and their ease of use, as well as the possibility of their application in other Andean contexts. Lastly, I examined the significance of the results as they relate to the intersection of stress, health, and Chachapoya social complexity. In the following chapter, I will provide some concluding statements, indicate the limitations of this study, and provide future considerations for further research in the topic of stature, health, and social complexity.

CHAPTER SIX: CONCLUSIONS

Bioarchaeological analyses of human stature in the past have the ability to shed light on patterns of health and society. Until now, stature estimations and osteometric data have been rarely examined or published. The current study has demonstrated the excellent potential of osteometric analyses in the interpretation of environmental pressures, socio-cultural organization, and gender disparities of past cultural groups. The methodology presented in this study has also proven successful for application to commingled remains, thereby providing further evidence in the interpretation of such contexts. Lastly, this study has demonstrated that the current approach of stature estimation through traditional LRFs in bioarchaeological contexts is inadequate. In order to avoid the skewing of results, greater effort is required on the part of investigators to verify that the regression formulae being utilized are appropriate for their sample. Bioarchaeological investigations not only concern understandings of the past, but shed light on modern human physical form and the biocultural factors that influence it. The complex nature of human stature create conflicting interpretations and unreliable results. The best practice to reduce these inconsistencies is to include the entire ecogeographic context in the biocultural processes affecting stature in ancient populations.

Research and Limitations

While standing height alone may not be suitable to examine social complexity or environmental stress, the intersection of stature and cultural material provide one line of evidence examining these factors. Stature mean and range for the Chachapoya region was found to be similar to that observed in other Andean regions that differed in subsistence strategy, social complexity, and environmental pressures. Therefore, variance in stature within a population alone is not a suitable metric for cross-cultural comparisons of social complexity or differentiation. However, comparisons of stature between sites of the same cultural group provide more consistent results to interpret, which can provide meaningful data in conjunction with cultural material. Cross-cultural comparisons of stature in the Andean region also suffer from minimal verification of the appropriate methods for stature estimation. Results from this study strongly indicate the necessity of reliable regression formulae created from the most similar reference populations possible, such as Pomeroy and Stock (2012) for Andean samples or the formulae presented in this study for the Chachapoya, in order to avoid skewed results.

The assumption that sexual dimorphism must necessarily be corrected in stature estimations is also challenged by the results of this investigation. Previous researchers (Béguelin, 2011; Genovés, 1967; Pomeroy and Stock, 2012; Raxter et al., 2006; Trotter and Gleser, 1952) have made the assumption that a 7-8% sexual dimorphism present in a population must be taken into account when creating regression formulae. This is accomplished by separating the sample into males and females and creating separate regression formulae for each. This study, however, has demonstrated that the small percentage of dimorphism and the overlap that exists in osteometric data between males and females leads to precision that still fits within the standard error of each regression formula. The main advantage of non-gendered formulae is their possible application to individuals whose biological sex may be unknown. An assumption of sex when using gendered regression formulae may lead to an error that is larger than the standard error of non-gendered formulae. As such, the stature estimation formulae created in this study may be used for any commingled remains for which the sex is unknown, thus providing metric data from commingled remains with reduced possible error from assumptions.

When examining the effects of external pressures on stature, limb proportion ratios are more meaningful than estimated statures. Previous research (Béguelin, 2011; Pomeroy and Stock, 2012) has established crural and brachial indices to be significantly affected by environmental pressures, and this study has demonstrated that the effects of these variables on stature are more difficult to interpret. Unfortunately, this study did not examine appendicular indices as they were not included in the original research questions, but the results clearly validate their necessity in future morphological investigations. Bilateral asymmetry has also been suggested as a marker of stress during growth and development. The poorly preserved and incomplete nature of many archaeological samples and commingled contexts, and these samples in particular, make such investigations difficult to pursue, and thus this study did not address patterns of asymmetry within individuals.

Logistic regression estimations of sex for commingled remains proved highly successful and comparably as reliable as morphological estimations from the cranium. Thus, these metrics may provide further evidence for the estimation of sex from an individual, or provide new lines of inquiry if the postcranial metrics of an individual do not match the pelvic and cranial morphological estimations. These results offer new opportunities in osteological and bioarchaeological research. Regrettably, the sex estimation regression formulae need further testing with other populations to determine their applicability across the region. For now, their use as a tool in bioarchaeological analyses must be restricted to the Chachapoyas region until further studies have been conducted and more data have been gathered.

The results of this investigation provide further support for the necessity of consistently recording postcranial metrics in bioarchaeological studies (Buikstra and Ubelaker, 1994). Osteometric data allow investigators to examine behavioral and environmental factors of past cultural groups that may be inaccessible without them. Humans are a highly diverse species, allowing us to adapt to environments of climatic extremes, through biological and cultural processes. All of the processes affecting the human form are interconnected, thus these variables must be controlled and examined in studies dealing with their intersection. This investigation has demonstrated that in order to understand humanity, both past and present, it is necessary to explore physical morphology and test for the effects that result from the interplay of environment and culture on the development of adult human stature.

Future Considerations

Future cross-cultural comparisons of adult standing height and its implication for health must account for the effects of environmental and cultural pressure. Due to time and sample constraints, this investigation was unable to examine certain properties of skeletal morphology that may be useful in future studies, such as bilateral asymmetry and appendicular indices. These indices have previously proven useful during investigations of nutritional deficiencies and extrinsic pressures on growth (Bailey et al., 2007; Bogin et al., 2007; Pinhasi et al., 2011). If an investigation can gather an adequate cross-cultural sample with excellent preservation of all appendicular elements, these indices will provide further understanding on human growth and development in the past.

Interpretations of stature and its relation to extrinsic factors must be controlled with better understanding of the genetic potential for stature. Epigenetic research is a promising avenue of future investigation. Genetic studies have suggested the complexity of DNA regarding stature, but the possibility that environmental changes and familial histories affect physical morphology is fast becoming a new direction of research (Bogin and Varela-Silva, 2010; Vercellotti et al., 2014; Wood et al., 2014; Yang et al., 2010). The importance of the intersection between culture, behavior, and genetics means that explorations of epigenetics should be conducted by individuals with a biocultural perspective, such as biological anthropologists, and not be left to purely biological interpretations (Jablonka and Lamb, 2007).

More directly, further research into the application of logistic regressions for sex estimation must be conducted before this method can be applied outside of the Chachapoyas region. One possible line of inquiry arising from this application is the use of Multiple Discriminant Analysis (MDA), which may be applicable and more reliable than logistic regression. Its application and difficulty of use must be examined to create a viable method for bioarchaeological investigations. Thus, my recommendations for future bioarchaeological studies include:

1. Application of the Anatomical stature estimation method to any viable sample.
2. If Anatomical methods are not possible, the application of regression formulae created specifically for the sample in question or a population from a geographically and environmentally similar location.
3. The use of the tibia as the primary appendicular element for estimation of stature.
4. When applying logistic regression formulae for the estimation of sex from the Chachapoya region, the most accurate element is the humerus using the humeral head diameter and maximum length metrics.
5. Stature alone is too complex and multifactorial to be effectively used as a single indicator for interregional comparisons of health.

This study has clearly demonstrated the ineffectiveness of comparing estimated mean stature of ancient populations to assess their relative health, and highlighted the necessity of understanding the intersection of culture, stature, and biology in such investigations.

APPENDIX A: ANATOMICAL METHOD DATA COLLECTION SHEET

Anatomical Method Data Collection Sheet

Site: ____________________ **Excavation Year:** _________ **Obs:** ___________ **Date:** ______________

Site Location: ____

Individual: ____ **Method Completeness:** ________%

Condition: good / fair / poor **Sex:** ______ **Age Category:** ______________ **Mean Age:** ________ **yrs.**

Cranial Height: ________________**mm**

C2 (Including Dens): ____________**mm**

C3: ________________**mm**

C4: ________________**mm**

C5: ________________**mm**

C6: ________________**mm**

C7: ________________**mm**

T1: ________________**mm**

T2: ________________**mm**

T3: ________________**mm**

T4: ________________**mm**

T5: ________________**mm**

T6: ________________**mm**

T7: ________________**mm**

T8: ________________**mm**

T9: ________________**mm**

T10:_______________**mm**

T11:_______________**mm**

T12: _______________**mm**

L1: ________________**mm**

L2: ________________**mm**

L3: ________________**mm**

L4: ________________**mm**

L5: ________________**mm**

S1: ________________**mm**

Femur (Bicondylar Length): _____________**mm**

Femur (Max. Length): _________________**mm**

Tibia (CLT; See Raxter): ________________**mm**

Talus-Calcaneus Height: _____________**mm**
(See Raxter et al. 2006)

Calcaneus Length: _______________**mm**

Calcaneus Breadth: ______________**mm**

Sum all measurements and convert to cm:

Skeletal Height (cm): _______________

Formula (as per Raxter et al. 2006)

Living Stature = (1.009 x Skeletal Height) – (0.0426 x mean age) + 12.1

Living Stature (cm): _______________ **± 4.5 cm**
(95% C.I.)

Comments: ______________________________

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APPENDIX B: KUELAP APPENDICULAR DATA – HUMERUS

Kuelap Individual ID	Sex	Side	Humeral Length (mm)	Humeral Head (mm)	Humeral Breadth (mm)	Humeral AP (mm)	Humeral ML (mm)
KSPlatC E3-VIIa ENT39A	F	L	254	36.15	37.72	13.13	16.9
K-PAS-MO ENT7 adu1	F	L	254	34.1	-	17.7	18.2
K-PAS MO -VIII U' ENT79	F	R	255	37.21	39.38	17.44	16.75
KCPlatII -IIIÑ Ent2	F	L	256	37	37.8	18.4	17.8
K-PAS-MO -VIII T' ENT18B	F	L	260	38.5	36.3	17.2	17.1
KSPlatI IIIÑ Ent1C	F	R	265	38.2	38.8	17.8	20.9
K-PAS MO -VIII U' ENT65b	F	R	265	37.02	-	21.34	20.83
K-PAC Est2 -IIN' Ent1b	F	R	265	38.32	39.58	19.88	18.14
KSPlatC E2-VIIz ENT4	F	L	266	36.9	38.3	18.7	17.2
KSPlatI IIIÑ Ent2C	F	L	267	34.9	-	17.9	17.7
K-PAC Est2 -III Ñ' Ent7A	F	L	268	35.56	38.38	18.73	18.38
K-SSbPl II -VII T Ent2	F	R	268	36.68	37.17	17.15	17.39
KPANTorVIIa Ent8	F	L	270	38.8	39.4	19.3	18.4
KSPlatC Patio-VIz ENT2A	F	L	271	39.6	38.06	17.5	14.95
K-PAS MO -VIII U' ENT59	F	L	272	32.72	36.4	19.12	16.84
K-PAS-MO ENT7 adu2	F	L	272	40.7	37.5	17.6	17.6
KSPlatC E4-VIa ENT66	M	L	273	36.47	38.44	19.05	16.54
K-PAC Est2 -III Ñ' Ent7m	F	L	274	38.99	37.29	16.9	17.38
K-PAC Est2 -IIN' Ent1a	F	R	274	38.83	40.05	18.9	18.37
K-PAS MO -VIII U' ENT78	F	R	277	37.63	39.76	19.64	18.11
KC E4 IVB ENT5a	M	L	278	40.7	41.04	20.21	18.17
KSPlatC Patio-VIz ENT3	F	R	278	39.52	35.41	17.88	21.2
KSTin-Vv Ent5m	M	L	279	42.8	41.7	21.2	18.4
KSPlat2 E10 -IVS ENT2	F	L	279	-	42.7	18.29	21.04
K-PAS-MO -VIII U' ENT77b	F	R	279	43.77	43.63	20.51	20.94
KSTin-Vv Ent5	M	R	280	42.2	41.5	22.6	19.9
KSPlatC E1-VIIz ENT101	F	L	280	38.19	37.59	18.14	18.38
K-PAS MO -VIII U' ENT53	F	R	280	38.26	38.01	18.67	17.52
K-PAC Est2 -IIN' Ent1c	F	R	280	39.51	38.02	19.71	19.16
K-PAC Est2 -III Ñ' Ent7m	F	L	281	37.8	40.15	17.78	19.56
K-TM E38 -VIII V Ent1	F	L	282	39.85	39.99	18.77	17.41
K-TM E38 -VIII V Ent1	F	R	282	40.18	40.45	18.17	19.38
K-PAC Est2 -IIN' Ent3b	F	R	282	39.79	38.38	19.72	18.67
KSPlatC E2-VIa' ENT14	M	L	283	45.63	47.66	18.62	21.12
KSPlatC E6-VIIIz-VIIIa' ENT87	M	R	283	42.01	44.61	-	-
KSPlatC E6-VIIIz-VIIIa' ENT85	F	L	283	38.08	39.03	17.53	18.27
K-PAS MO -VIII T' ENT36a	F	L	284	-	39.6	19.31	17.36
K-PAS E1 -VI Q' T1ENT2	M	R	285	39.45	35.57	20.45	20.63
K-PAS MO -VIII U' ENT49b	F	L	285	44.1	45.15	19.5	20.34
K-PAS MO -VIII U' ENT58	F	R	286	37.32	40.57	19.01	18.29
KSPlatC E6-VIIIz-VIIIa' ENT90A	M	L	287	41.81	43.04	19.16	21.13
K-PAS-MO ENT5 adu1	M	L	287	41.2	41.4	22.8	21
KSSbPlt1 -IIPE9 Ent1	M	R	287.0	-	43.9	19.3	22.9
KSSbPlt1 -IIPE9 Ent1	M	R	287	-	43.9	19.3	22.9
KSPlatI IIIÑ Ent2B	F	R	287	-	41.1	18.9	21.4
KSSbPlt1 -IPE8 Ent3	M	L	288.0	39.9	42.3	17.6	19.3

Kuelap Individual ID	Sex	Side	Humeral Length (mm)	Humeral Head (mm)	Humeral Breadth (mm)	Humeral AP (mm)	Humeral ML (mm)
KSSbPlt1 -IPE8 Ent3	M	L	288	39.9	42.3	17.6	19.3
K-SE4-E3	M	R	288	45	-	-	-
K-SE3-E1	M	R	289	45	-	-	-
KSPlatC E6-VIIz-VIIa'-VIIIz ENT79	F	L	289	39.57	37.36	15.3	17.05
K-PAC Est2 -IIN' Ent5b	F	L	289	39.85	38.51	20.13	17.93
KC E4 IVB ENT5b	F	R	289	38.43	43.04	20.63	19.29
KCAc1-IIM ENT1	F	L	289.5	40.49	40.37	14.24	19.21
KSPlatC E3-VIIa ENT40	M	L	290	43.11	43.48	16.19	18.91
K-PAC Est2 -IIN' Ent2G	M	L	290	41.11	41.38	18.88	18.43
KSPlatC E3-VIIa' Ent32	M	R	290	40.9	40.1	19.6	13.6
K-TM E40 -IX U Ent2	M	R	290	42.71	45.29	20.55	21.72
K-TM E52 -VZ Ent1	F	L	290	39.45	41.44	19.63	19.51
K-PAS MO -VIII U' ENT66	F	R	290	38.04	35.13	18.29	18.58
K-S-TM E51 -IV A' ENT1b	M	L	291	40.72	44.7	18.76	18.95
KSPlatC E3-VIIa' ENT35b	M	R	291	42.04	42.77	18.06	20.23
K-PAS MO -VIII U' ENT63	F	R	291	39.37	41.34	19.28	16.54
KSPlatI IIIÑ Ent5	M	L	292	40.6	40.2	17.8	18.1
K-PAS-MO -VIII T' ENT31	M	L	292	45	40	18.5	19.9
K-PAS-MO -VIII T' ENT27	F	L	292	36.6	38	19	19.9
KSPlatC E2-VIIz ENT15	M	L	293	40.7	37.77	20.78	18.52
K-PAS E1 -VI Q' T1ENT1	M	R	293	42.03	43.25	20.7	22.46
KSPlatC E6-VIIIz-VIIIa' ENT84	M	L	294	39.89	41.56	18.06	18.05
KPANTorVIIa Ent7	F	L	294	38.5	38.8	18.1	16.9
K-SbPltII -VI U Ent1	M	L	295	43.61	45.15	18.12	21.07
K-SSbPl II -VII T Ent3	M	R	295	40.09	43.17	18.74	17.31
K-PAC Est2 -IIN' Ent2F	M	R	295	41.66	43.09	21.07	20.25
K-PAS MO -VIII U' ENT64	F	L	295	39.6	38.59	19.83	19.57
K-CE4-E1a	F	R	295	41	-	-	-
K-PBN ME Ent1	F	R	295	42.06	41.95	18.53	19.07
KSPlatC E6-VIIz-VIIa'-VIIIz ENT80	M	L	296	41.5	45.93	21.06	20
K-PAS MO -VIII T' ENT40	M	L	296	45.63	48.77	21.43	23.49
KSPlatC E2-VIIa' ENT20a	M	L	297	42.6	43.4	19.8	21
KSPlatC E2-VIIa' ENT5	M	R	297	43.2	45	20.2	22.3
KSPlatC E2-VIIz ENT11	M	L	298	43.87	41.95	17.7	19.53
K-CE4-E1b	M	R	298	44	-	-	-
KCPlatII -IIIÑ Ent4	M	L	299	40	43.9	20.3	20.8
KSSbPlt1 -IOE8 Ent2	M	R	299.0	43.7	43.7	19.5	18.9
KSSbPlt1 -IOE8 Ent2	M	R	299	43.7	43.7	19.5	18.9
K-SSbPl II -VII T Ent1	M	R	299	42.47	43.31	20.32	19.52
KSPlatC E2-VIIa' ENT7	M	L	300	44.66	47.11	21.39	20.04
KSPlatC E6-VIIIz-VIIIa' ENT88	M	L	300	42.34	42.08	17.46	19.65
KSPlatC E2-VIIa'-VIa' ENT6	M	L	302	45.45	42.75	18.87	18.9
KSPlatC E2-VIa' ENT19a	M	L	302	43.48	42.56	16.47	18.56
KSPlatC E6-VIIz,-VIIa' ENT74	M	L	302	44.71	41.2	-	-
K-SbPl II -VIII S E1 Ent1b	M	L	302	43.02	45.45	18.88	20.33
K-PAC Est2 -IIN' Ent2D	M	L	302	45.06	45.9	19.48	21.17
K-SbPltII -VI U Ent2	M	L	302	44.47	46.06	22.72	23.74

Kuelap Individual ID	Sex	Side	Humeral Length (mm)	Humeral Head (mm)	Humeral Breadth (mm)	Humeral AP (mm)	Humeral ML (mm)
K-PAS-MO ENT11	M	L	303	45.6	42.8	19.4	19.4
KSPlatC E6-VIIIz-VIIIa' ENT86	M	R	303	45.37	-	-	-
KSPlatC E2-VIIa' ENT8a	M	R	304	46.17	45.97	22.02	23.92
KSPlatC E6-VIIIz-VIIIa' ENT82	M	L	305	43.4	45.67	21.1	20.41
K-PAS MO -VIII U' ENT59	M	L	305	37.17	38.21	17.79	18.35
KSTIN -IIU Ent12	M	R	305	41.5	44.5	21.6	24.2
KSTin-IVv Ent10	M	L	306	41.4	44	20	17.6
K-PAS E1 -VI Q' T1ENT5	M	L	306	43.7	45.35	19.25	22.06
K-PAC E1 -III G ENT1	M	L	306	43.83	44.02	19.97	21.57
K-PAS MO -VIII U' ENT49a	M	L	306	46.42	48.46	20.76	20.97
K-PAC E2 -II N' Ent1b	M	L	306	46.87	46.11	20.85	23.84
KSSbPlt1 IOE7 Ent1B	M	R	306.0	48.6	42.9	21.8	22.8
KSSbPlt1 IOE7 Ent1B	M	R	306	48.6	42.9	21.8	22.8
KSPlatC E6-VIIIz-VIIIa' ENT83	M	R	306	43.98	44.66	19.75	18.64
K-PAC E1 -III G' Ent1	M	R	306	43.37	44.01	20.65	19.74
KCPlatII -IIIÑ Ent3A	F	R	306	40.8	46.3	21	19.8
KSPlatC E4-VIa ENT57	M	L	307	45.88	43.15	19.96	18.85
K-SbPl II -VIII S E1 Ent1a	M	L	307	44.8	46.68	21.64	22.77
K-PAS-MO ENT13 adu	M	L	307	43	43.3	18.8	18.2
KSPlatC E3-VIIa' ENT36	M	R	307	47.72	46.93	22.26	22.98
KSPlat2 E8 -IIIR ENT1	M	R	307	42.92	41.84	19.59	19.23
KSPlatC E2-VIIa' ENT21	M	L	308	43.5	47.5	17	17.5
KCPlatII -IIIÑ Ent1	M	R	308	42.2	44.8	16.1	17.1
KSPlatI IVÑ Ent7	M	L	309	47	48.8	21.5	21.8
KSPlatC E6-VIIIz-VIIIa' ENT81	M	L	310	45.43	43.64	20.79	20.13
K-PAN AC3 Ent1b	M	L	310	43.06	43.39	19.7	19.86
K-SbPl II -VIII S E1 Ent1c	M	L	310	42.15	43.56	19.78	21.12
K-PAS-MO -VIII U' ENT77a	M	L	310	42.4	42.36	21.96	21.42
K-CE3-E1	M	R	310	43	-	-	-
K-PAS-MO -VIII T' ENT20C	M	R	310	44	56.7	-	-
KSTIN -VU Ent2	M	L	311	45.3	45.4	19.8	19.9
K-TM MNO Ent1	M	L	311	42.81	48.35	20.6	25.16
K-PAS-MO -VIII T' ENT29	M	L	311	44.1	42.7	19.8	19.5
K-PAC Est2 -IIN' Ent3c	M	R	311	43.11	45.19	20.07	22.66
K-PAC Est2 -IIN' Ent3a	M	R	312	44.43	46.35	19.93	20.12
K-PAC Est2 -III Ñ' Ent7F	M	L	313	44.87	46.04	21.51	19.78
K-PAS-MO ENT4A	M	L	313	46.8	48.4	22.2	25
K-PAC E2 -II N' Ent1a	M	L	314	45.43	45.55	20.43	21.33
K-TM E40 -IX U Ent1	M	R	315	42.37	41.38	17.6	19.34
KSSbP1IIIOE4Ent1A	M	R	316.0	-	43.6	21.5	30.9
KSSbP1IIIOE4Ent1A	M	R	316	-	43.6	21.5	30.9
K-PAS MO -VIII U' ENT74	M	L	317	42.86	43.93	19.62	21.34
K-PAS-MO -VIII T' ENT18A	M	L	321	45	42.2	21.5	20.7
K-PAS MO -VIII T' ENT44	M	L	322	42.41	46.14	22.15	20.91
K-PAS-MO -VIII U' ENT73b	M	L	322	46.4	-	-	-
KSPlatC E6-VIIz-VIIa' ENT69	M	R	323	42.5	43.7	19.45	21.92
K-PAS E1 -V Q' INT ENT1	M	R	326	44.53	45.11	19.21	21.96

Kuelap Individual ID	Sex	Side	Humeral Length (mm)	Humeral Head (mm)	Humeral Breadth (mm)	Humeral AP (mm)	Humeral ML (mm)
K-TM E33 -IX W Ent1	M	R	326	47.23	44.66	-	-
K-PAS MO -VIII U' ENT47	M	L	327	45.85	46.7	21.04	22.65
K-PAS MO -VIII U' ENT53	M	L	329	47.89	43.17	21	23.51
KSPlatC E4-VIa ENT65	F	L	334.5	40.54	41.06	20.63	20.76
KSPlatC E9-VIa' ENT98	M	R	338	43.3	43.63	20.91	21.5

APPENDIX C: KUELAP APPENDICULAR DATA – FEMUR

Kuelap Individual ID	Sex	Side	Femoral Length 1 (mm)	Femoral Length 2 (mm)	Femoral Head (mm)	Femoral Breadth (mm)	Femoral AP (mm)	Femoral ML (mm)
KCPlatII -IIIÑ Ent2	F	L	347	-	37.80	-	23.3	20.6
K-PAS MO -VIII U' ENT65b	F	R	350	-	37.50	59.10	22.2	21.4
K-PAC Est2 -III Ñ' Ent7A	F	L	351	364	36.40	57.30	24.5	22.5
K-PAS-MO -VIII U' ENT68b	F	L	353	-	35.90	57.00	22.6	24.7
KSPlatI IIIÑ Ent1C	F	R	355	-	39.40	-	22.8	21.7
KSPlatC Patio-VIz ENT1B	F	R	361	364	38.00	63.50	26.3	23.4
K-SSbPl II -VII T Ent2	F	R	362	368	37.87	64.16	25.17	26.04
K-PAS-MO -VIII T' ENT28b	F	L	364	369	36.62	63.92	25.5	21.63
K-PAC Est2 -IIN' Ent1b	F	R	365	372	-	67.15	26.09	26.35
K-PAS MO -VIII U' ENT78	F	R	367	-	41.50	62.90	23.3	19.9
KSPlatI IIIÑ Ent2B	F	L	367	368	41.60	66.90	25.8	23.2
K-PAC Est2 -IIN' Ent1a	F	L	372	-	37.97	62.54	23.5	22.01
K-PAC Est2 -IIN' Ent5b	F	L	372	-	36.37	56.88	-	-
KSPlatC E2-VIIz ENT4	F	L	372	377	39.62	62.40	24.94	24.05
KSPlatC E4-VIa ENT65	F	L	374	-	34.70	59.50	22.6	20.8
KC E4 IVB ENT5a	M	L	374	-	40.30	-	23.3	23.1
KPANTorVIIa Ent8	F	L	375	-	39.40	-	23.4	23.4
KSPlatC E1-VIIz ENT101	F	L	375	383	39.20	59.60	24.4	24.9
KSPlatC E6-VIIIz-VIIIa' ENT85	F	L	376		40.40	64.60	23.3	23.9
K-PAS MO -VIII U' ENT53	F	L	377	385	40.55	64.52	25.71	24.86
K-PAC Est2 -III Ñ' Ent7m	F	L	378	382	39.90	62.60	25.1	24.19
KSPlatC E2-VIa' ENT14	M	L	380	-	42.70	65.30	32	24.3
KC E4 IVB ENT5b	F	R	380	-	42.60	65.80	27.2	23.4
K-TM E52 -VZ Ent1	F	L	380	-	37.30	59.70	25.8	22.7
K-SE4-E2	F	R	381	-	40.00	-	24.4	22.9
K-SE6-E1	F	R	381	385	39.59	63.44	26.89	23.12
KSPlatC E3-VIIa' ENT35b	M	L	382	387	40.58	63.70	26.52	23.58
K-PAC Est2 -IIN' Ent1c	F	L	384	37.5	39.50	-	25	23.2
KSPlat2 E10 -IVS ENT2	F	R	384	390	39.57	62.99	25.22	24.78
K-TM E38 -VIII V Ent1	F	L	385	387	42.29	72.64	28.63	26.22
K-PAS MO -VIII U' ENT49b	F	R	385	387	38.60	67.60	25.8	23
K-TM E38 -VIII V Ent1	F	R	385	384	38.34	55.39	22.61	22.34
K-PAC E1 -II H' Ent1	M	L	385.5	392	41.84	62.35	25.73	26.59
K-PAS MO -VIII U' ENT56	F	L	387	393	40.22	62.98	24.04	23.72
K-PAS MO -VIII U' ENT58	F	R	387	392	38.41	65.27	25.25	23.72
KCAc1-IIM ENT1	F	L	388	390	45.57	76.37	28.29	24.62
KPANTorVIIa Ent7	F	L	388	392	41.62	68.64	28.93	26.11
K-PAS MO -VIII T' ENT35a	F	L	390	403	41.92	68.04	28.54	25.64
K-PAC Est2 -IIN' Ent2A	F	R	390	385	41.00	-	26	25
KSPlatC E6-VIIz-VIIa'-VIIIz ENT79	F	L	390	-	40.00	-	25	23
KSSbPlt1 -IPE8 Ent3	M	R	391	396	41.84	67.56	28.35	22.98
KSSbPlt1 -IPE8 Ent3	M	R	391	394	39.60	66.90	25.89	22.79
K-PAS MO -VIII U' ENT50	F	L	391	395	41.04	66.72	28.54	23.94
KSPlatC E6-VIIIz-VIIIa' ENT83	M	L	392	-	40.70	61.60	39.8	25.1
K-PAS-MO -VIII T' ENT31	M	L	392	-	45.09	72.57	28.19	24.66
KSPlatC E2-VIIa' ENT5	M	L	394	-	41.46	66.99	26	24.45

Kuelap Individual ID	Sex	Side	Femoral Length 1 (mm)	Femoral Length 2 (mm)	Femoral Head (mm)	Femoral Breadth (mm)	Femoral AP (mm)	Femoral ML (mm)
KSPlatC E6-VIIIz-VIIIa' ENT88	M	L	394	397	40.77	62.73	27.71	24.83
K-SSbPl II -VII T Ent3	M	L	394	398	38.84	62.54	-	-
K-PAC Est2 -IIN' Ent2B	M	L	395		40.90	65.10	24.1	24.1
K-PAS-MO -VIII T' ENT29	M	L	395	397	42.09	66.46	26.88	24.59
K-PAC Est2 -IIN' Ent2F	M	R	396	407	41.74	63.13	25.9	26.41
K-SbPltII -VI U Ent2	M	R	396	400	37.22	61.92	24.79	23.91
KSPlatC E2-VIIz ENT15	M	R	396	399	41.14	69.77	31.51	26.28
K-SbPltII -VI U Ent1	M	R	398	397.5	40.27	61.91	21.63	22.94
K-PBN ME Ent1	F	L	399	402	38.80	65.70	23.7	21.6
K-PAS MO -VIII T' ENT40	M	L	399	401	41.76	65.36	25.49	22.24
K-PAC Est2 -III Ñ' Ent7m	M	L	399	401	41.40	65.91	29.65	24.94
K-SE4-E3	M	R	400.5	403	41.43	63.35	26.79	23.45
KSPlatC E2-VIa' ENT19a	M	L	401	-	40.80	65.60	27.5	24.4
KSPlatC E3-VIIa' Ent32	M	R	401.0	402.0	44.30	69.60	27.9	23.4
KSSbPlt1 -IOE8 Ent2	M	L	401	402	44.30	69.60	27.9	23.4
KSSbPlt1 -IOE8 Ent2	M	L	401	406	42.75	71.70	27.8	25.17
KSPlatC E2-VIIa' ENT9a	M	L	402	405	41.93	65.73	27.33	25.53
K-PAS-MO -VIII T' ENT27	F	L	402	402	43.60	69.00	27.2	25.8
K-PAS MO -VIII U' ENT64	F	R	405	409	45.60	-	30.1	24.9
KSPlatC E4-VIa ENT51	M	R	405	406.5	42.45	-	26.15	23.21
KSPlatC E6-VIIIz-VIIIa' ENT90A	M	R	405	406	42.76	69.91	29.58	23.38
KSPlatC E4-VIa ENT57	M	L	405	409	43.09	72.63	27.9	23.9
KSTin-Vv Ent5m	M	L	406	406	43.80	71.50	30.7	24.3
K-SE3-E1	M	R	406	411	43.41	76.80	30.29	25.51
KSPlatC E6-VIIIz-VIIIa' ENT87	M	R	406	412	45.41	69.03	31.19	26.1
K-PAS E1 -VI Q' T1ENT1	M	R	407	409	40.59	68.71	27.03	23.54
K-PAS MO -VIII T' ENT36a	F	R	407	411	43.89	70.94	25.33	21.85
K-PAS E1 -VI Q' T1ENT2	M	L	407	412	43.02	69.56	27.6	24.77
KSPlat2 E8 -IIIR ENT1	M	R	408	410	44.52	70.89	31.03	26.53
K-PAS MO -VIII U' ENT63	F	R	408	413	43.76	72.55	28.3	24.12
KSPlatC E6-VIIIz-VIIIa' ENT92	M	L	408	401	45.00	-	26	26
KSPlatI IIIÑ Ent5	M	L	409	411	43.48	-	24.3	23.19
KSPlatC E6-VIIIz-VIIIa' ENT81	M	L	409	413	42.90	70.40	26	23
KSPlatC E6-VIIIz-VIIIa' ENT93A	M	L	410	-	42.30	71.00	30	23.6
K-TM E40 -IX U Ent1	M	L	410.0	411.0	43.20	68.00	25.9	24.7
KSSbPlt1 -IIPE9 Ent1	M	L	410	411	43.20	68.00	25.9	24.7
KSSbPlt1 -IIPE9 Ent1	M	L	410	-	-	68.90	26.6	20.9
KSPlatC E6-VIIIz-VIIIa' ENT84	M	L	410	414	40.20	64.90	27.3	25.5
KSPlatC E3-VIIa' ENT36	M	R	411	415	42.47	65.32	30.01	24.74
KCPlatII -IIIÑ Ent3A	F	L	412	415	42.71	73.29	29.75	22.83
K-PAC Est2 -IIN' Ent5a	M	L	412	416	41.80	-	-	-
K-PAC Est2 -IIN' Ent2D	M	L	413	-	41.50	71.30	25.8	24.8
KSPlatC E2-VIIa'-VIa' ENT6	M	R	413	-	46.90	73.10	30.2	27.5
K-TM E40 -IX U Ent2	M	R	413	417	43.97	71.62	29.3	24.38
K-PAS E1 -VI Q' T1ENT6	M	L	414	418	44.00	72.20	27.6	25.2
KSPlatC E6-VIIIz-VIIIa' ENT86	M	L	414	407	44.00	-	30	24
KSPlatC E2-VIIa' ENT21b	M	R	414	418	42.57	72.28	-	-

Kuelap Individual ID	Sex	Side	Femoral Length 1 (mm)	Femoral Length 2 (mm)	Femoral Head (mm)	Femoral Breadth (mm)	Femoral AP (mm)	Femoral ML (mm)
K-PAC E1 -III G' Ent1	M	R	414	418	45.70	69.73	26.57	26.96
KSPlatC E2-VIIa ENT23	M	R	414	421	40.62	61.64	28.43	27.73
KSPlatC E2-VIIa' ENT20a	M	L	415	420	41.59	71.44	32.91	23.1
K-SbPl II -VIII S E1 Ent1a	M	L	416	-	42.60	71.10	27.2	25.8
K-PAS-MO ENT6m	M	L	416	417	43.38	73.48	28.84	26.4
K-SbPl II -VIII S E1 Ent1b	M	L	416	421	40.99	63.79	29.11	24.63
K-PAC Est2 -IIN' Ent3c	M	L	417	-	43.70	75.00	8.8	26.7
K-PAC E1 -III G ENT1	M	L	417	420	-	-	30.65	27.06
KSPlatC E6-VIIIz-VIIIa' ENT82	M	R	418	423	42.30	69.60	27.3	23.4
K-PAS MO -VIII U' ENT48	M	R	418	419	46.65	66.39	26.97	26.73
K-CE4-E1a	F	R	418	419.5	42.70	-	27.07	24.33
KPANTorVIa Ent6m	M	L	418	423	43.89	-	28.88	25.7
KSPlatC Patio-VIz ENT1A	M	L	419.0	422.0	46.90	-	30.7	27.3
KSSbPlt1 IOE7 Ent1B	M	R	419	422	46.90	-	30.7	27.3
KSSbPlt1 IOE7 Ent1B	M	R	419	418	42.05	65.57	30.82	26.91
KSTIN -VU Ent2	M	L	419	422	45.95	74.43	30.53	25.69
K-PAS E1 -VI Q' T1ENT5	M	L	419	420	43.30	68.90	26.6	25.1
K-CE4-E1b	M	R	420	423	46.15	76.41	31.29	25.27
K-PAS-MO -VIII U' ENT77a	M	R	420	425	41.62	74.07	27.79	24.42
K-SSbPl II -VII T Ent1	M	L	420	423	45.42	73.50	29.39	25.95
K-SbPl II -VIII S E1 Ent1c	M	R	420	424	43.38	71.15	30.37	24.99
KCPlatII -IIIÑ Ent4	M	L	421	425	42.87	76.27	29.84	26.44
KSPlatC E4-VIa ENT66	M	L	422	425	43.14	69.01	26.86	25.71
K-PAS MO -VIII U' ENT74	M	L	422	423	44.17	74.14	24	24.43
KSPlatI IVÑ Ent7	M	R	422	425	44.14	74.00	33.69	25.75
K-PAC Est2 -III Ñ' Ent7F	M	L	422.5	424	43.19	71.58	24.25	22.92
KSPlatC E2-VIIa' Ent18a	M	L	423	426	46.90	79.00	26.8	24.8
K-PAS MO -VIII T' ENT44	M	L	423	426	46.67	80.96	31.33	25.1
KSPlatC E3-VIIa ENT34	M	R	423	424	41.50	68.40	29.5	22.9
K-PAS-MO -VIII T' ENT30	M	L	424	-	42.60	-	30.4	26.8
KCPlatII -IIIÑ Ent1	M	R	424	425	43.48	69.99	30.67	23.56
K-PAS MO -VIII U' ENT67b	M	L	424	428	45.37	75.09	30.29	26.72
KSPlatC E2-VIIa' ENT21	M	R	424	424	44.56	74.19	33.25	25.78
KSPlatC E2-VIa' ENT12a	M	L	424	425	46.56	73.40	30.31	24.51
KSPlatC E2-VIIa' ENT8a	M	L	425	427	49.00	76.11	28.65	25.24
K-PAS-MO -VIII T' ENT18A	M	L	425	420	43.00	-	28	26
K-CE3-E1	M	R	426	428	45.90	71.10	30.2	25
KSTIN -IIU Ent12	M	L	427	-	46.22	73.71	28.91	25.18
KSSbP1IIIOE4Ent1A	M	R	427	428	42.75	61.46	24.29	23.38
KSSbP1IIIOE4Ent1A	M	R	427.0	-	44.90	-	31.2	26.7
K-PAC Est2 -IIN' Ent3a	M	R	427	-	44.90	-	31.2	26.7
K-PAS MO -VIII U' ENT47	M	L	428	430	47.20	80.70	29	24
KSTin-IVv Ent10	M	L	428	433	46.45	73.06	30.69	25.75
KSPlatC E4-VIa ENT53	M	L	429	425	45.00	-	31	28
KSPlatC E9-VIa' ENT98	M	R	429	433	45.19	71.43	27.83	27.02
K-PAS MO -VIII U' ENT49a	M	R	430	434	44.21	72.62	33.21	25.49
K-TM E33 -IX W Ent1	M	L	430	436	43.96	68.51	28.15	22.69

Kuelap Individual ID	Sex	Side	Femoral Length 1 (mm)	Femoral Length 2 (mm)	Femoral Head (mm)	Femoral Breadth (mm)	Femoral AP (mm)	Femoral ML (mm)
KSPlatC E2-VIIa' ENT7	M	L	431	-	45.30	-	30.2	24.7
KSPlatC E3-VIIa ENT46	M	L	431	-	46.30	-	30.5	27.6
KSPlatC E6-VIIz-VIIa'-VIIIz ENT80	M	L	431	434.5	42.55	66.20	28.18	23.42
KSPlatC E6-VIIIz-VIIIa' ENT90A	M	L	431	433	43.96	-	29.27	24.88
K-PAS E1 -V Q' INT ENT1	M	L	431	433	46.50	80.50	31.6	22.7
K-PAN AC3 Ent1b	M	L	432	435	44.71	72.63	30.2	27.12
K-TM MNO Ent1	M	L	433	-	49.30	78.50	28.2	26.59
K-PAC Est2 -IIN' Ent2G	M	L	433	436	43.10	-	-	-
K-PAS-MO ENT3 aduA	M	L	433	436	45.41	76.09	30.39	27.44
K-PAS-MO ENT4A	M	L	433	435	44.76	70.18	26.83	24.63
K-PAS-MO ENT11	M	L	435	435	45.80	73.20	27.1	26.8
K-PAC Est2 -III Ñ' Ent7m	M	L	436	436	44.00	72.80	24.2	24.9
KSPlatC E2-VIIa' ENT28	M	R	437	441	44.38	75.60	32.55	24.18
KSPlatC E6-VIIz-VIIa' ENT69	M	R	438	440	47.40	74.20	24.2	23
KSPlatC E6-VIIz-VIIa' ENT70A	M	R	439	445	47.35	79.10	35.32	25.89
KSPlatC E2-VIIa' ENT30	F	L	440	446	46.60	75.33	24.79	23.89
KSPlatC E6-VIIz-VIIa' ENT70B	F	L	440	445	46.10	70.80	32.1	27.8
KSPlatC Patio-VIz ENT2A	F	L	440	435	47.00	-	33	26
K-PAS-MO ENT2 aduB	F	L	442	445	45.60	74.50	30.2	28.8
K-PAS MO -VIII U' ENT44	F	L	445.0	454.0	45.10	74.00	27.2	24.4
K-PAS-MO -VIII T' ENT24	F	L	445	454	45.10	74.00	27.2	24.4
KSPlatC Patio-VIz ENT3	F	R	446	447	45.33	74.47	31.04	26
K-PAS MO -VIII U' ENT59	F	R	448	450	47.15	-	31.35	24.93
K-PAS MO -VIII U' ENT79	F	R	450	448	46.50	74.20	30.8	26.2

APPENDIX D: KUELAP APPENDICULAR DATA – TIBIA

Kuelap Individual ID	Sex	Side	Tibial Length (mm)	Tibial Plateau (mm)	Tibial Distal Breadth (mm)	Tibial AP (mm)	Tibial ML (mm)
K-PAC Est2 -III Ñ' Ent7A	F	L	282	61.40	28	25.3	19.9
KSPlatI IIIÑ Ent2C	F	L	287	53.90	26.9	25.6	17.7
KCPlatII -IIIÑ Ent2	F	L	289	64.76	23.31	24.47	19.66
K-SE4-E2	F	R	290	-	24.4	21.5	17.2
K-PAS-MO ENT7 adu1	F	L	292	-	-	27.3	16.8
K-PAS MO -VIII U' ENT78	F	R	297	61.80	22.8	24.1	21.5
K-PAS-MO ENT8 adu	F	L	297	61.80	25.8	23.1	206
K-PAS-MO -VIII T' ENT28b	F	L	300	62.40	25.6	25.4	17.8
K-SSbPl II -VII T Ent2	F	R	300	66.00	45	-	-
KSPlatC E1-VIIz ENT101	F	R	301	62.80	23.3	24.8	19.8
KSPlatI IIIÑ Ent1C	F	R	301	63.60	22.5	25.4	17.5
KPANTorVIIa Ent8	F	L	301	65.87	24.04	24.72	20.18
K-PAC Est2 -IIN' Ent1b	F	R	302	56.90	24.1	23	19.7
K-PAS MO -VIII U' ENT44	F	L	303	62.80	23.7	24.4	21.1
KSPlatl IIIÑ Ent2B	F	L	303	62.30	26.3	24.6	19.9
K-PAS-MO ENT7 adu2	F	L	303	63.58	25.88	23.51	21.3
K-SE4-E3	M	R	304	68.60	26.6	28	23
KSPlatC E4-VIa ENT65	F	L	305	-	23.65	24.86	16.87
KSPlatC E3-VIIa' ENT35b	M	R	306	67.20	24.5	24.5	20
K-PAS-MO ENT2 aduB	F	L	308	65.80	27.1	24.1	20.4
K-PAC Est2 -IIN' Ent5b	F	L	308	65.84	26.19	26.15	23.39
KSPlatC E6-VIIIz-VIIIa' ENT85	F	R	309	60.36	24.91	24.87	19.66
KC E4 IVB ENT5b	F	R	310	-	23.4	24.4	17.8
K-PAC Est2 -IIN' Ent1a	F	L	310	65.18	22.76	24.75	22.09
K-SE3-E1	M	R	310	65.90	24.7	26.4	18.9
KCAc1-IIM ENT1	F	L	311	67.80	26.5	26.7	27.5
KSPlatC E2-VIa' ENT14	M	R	312	73.00	46	-	-
K-PAC Est2 -IIN' Ent3b	F	L	312	65.95	25.56	28.83	18.78
K-PAC Est2 -III Ñ' Ent7m	F	L	313	68.42	27.74	27.54	20.03
K-CE4-E1a	F	R	313	-	26.4	29.8	21
K-PAS MO -VIII U' ENT45	F	L	314	64.97	25.52	26.52	19.9
K-PAC E1 -II H' Ent1	M	L	314	66.73	-	29.79	20.69
K-TM E38 -VIII V Ent1	F	L	314	67.85	27.29	27.92	21.19
KSPlat2 E10 -IVS ENT2	F	R	315	61.80	21.9	26.8	18.6
KSPlatC E2-VIIz ENT15	M	R	315	62.22	25.73	23.89	20.22
K-PAS MO -VIII T' ENT36a	F	R	316	68.02	25.32	26.67	22.21
K-TM E38 -VIII V Ent1	F	R	317	75.00	53	-	-
K-PAC Est2 -IIN' Ent1c	F	R	319	63.02	26.32	25.07	19.26
KSPlatC E2-VIIa' ENT7	M	L	320	66.50	25.5	26.7	18.9
KPANTorVIIa Ent7	F	L	320	75.64	30.17	29.49	23.79
KSPlatC E2-VIIa' ENT30	F	L	320	65.83	24.91	24.74	18.71
KSPlatC E6-VIIz-VIIa' ENT70B	F	R	321	64.30	27.8	24.9	22.7
KSTin-Vv Ent5	M	R	322	66.12	25.65	25.76	20.61
K-PAS-MO -VIII T' ENT17	F	L	324	70.00	38	-	-
K-PAS MO -VIII U' ENT58	F	R	325	-	-	30.9	21.9

Kuelap Individual ID	Sex	Side	Tibial Length (mm)	Tibial Plateau (mm)	Tibial Distal Breadth (mm)	Tibial AP (mm)	Tibial ML (mm)
K-PAS MO -VIII U' ENT63	F	R	325	64.41	25.15	27.76	18.55
K-PAS MO -VIII U' ENT53	F	L	326	68.70	28.5	26.8	23.4
KSSbPlt1 -IOE8 Ent2	M	L	326	65.79	24.61	27.93	19.31
KSSbPlt1 -IOE8 Ent2	M	L	326	64.05	26.85	27.08	18.75
K-S-TM E51 -IV A' ENT1b	M	L	326	66.10	27.86	25.8	18.74
KSTin-Vv Ent5m	M	L	327	73.29	26.62	27.26	26.65
K-PAC Est2 -III Ñ' Ent7m	M	L	327	68.74	26.05	29.86	19.01
K-PAC Est2 -IIN' Ent2B	M	L	327	67.61	25	26.85	22.19
KSPlatC E6-VIIz-VIIa'-VIIIz ENT79	F	L	327	64.57	22.6	26.09	21.02
K-PAS MO -VIII U' ENT50	F	R	327	67.11	25.98	25.61	19.85
KC E4 IVB ENT5a	M	L	328	68.54	28.16	26.73	22.48
KSSbPlt1 -IPE8 Ent3	M	R	328	-	-	30.85	19.2
KSSbPlt1 -IPE8 Ent3	M	R	328	65.00	25.3	25.4	23.4
K-PAC Est2 -IIN' Ent2A	F	R	328	61.34	21.88	26.41	19.92
KSPlatC E2-VIIa' ENT5	M	L	329	70.93	28.88	30.5	22.13
KSPlatC E6-VIIIz-VIIIa' ENT83	M	L	329	-	25.3	27.85	18.86
K-SbPltII -VI U Ent1	M	R	330	63.05	27.61	30.45	19.09
KSPlatC E6-VIIIz-VIIIa' ENT88	M	L	330	75.00	33.3	35.1	24.4
K-PAS MO -VIII T' ENT40	M	R	330	66.10	26.2	26.5	19
K-PAS MO -VIII T' ENT35a	F	L	330	69.75	27.26	29.63	24.2
KSPlatC E4-VIa ENT66	M	L	330	67.75	24.83	28.6	19.71
K-PAC Est2 -IIN' Ent2F	M	R	331	-	-	26.81	20.64
K-PAS-MO -VIII T' ENT31	M	L	333.0	68.40	27.4	26.2	24.7
K-CE4-E1b	M	R	333	68.40	27.4	26.2	24.7
KSPlatC E2-VIIa' ENT8a	M	R	334	70.26	27.86	26.74	21.23
K-SbPltII -VI U Ent2	M	R	335	73.20	33	31.2	22.2
KCPlatII -IIIÑ Ent3A	F	L	335	72.67	30.5	28.75	21.67
K-PAS MO -VIII U' ENT64	F	R	337	69.98	27.54	28.21	20.6
KSPlatC E2-VIIa'-VIa' ENT6	M	R	337	65.24	28.43	29.63	20.47
KSPlatC Patio-VIz ENT1A	M	R	337	-	-	-	-
K-PAS-MO ENT8 adu	M	L	338	70.66	29.24	29.99	21.96
KSPlatC E3-VIIa' ENT36	M	R	338.0	70.50	30.4	24.9	19.8
K-PAS MO -VIII U' ENT49a	M	R	338	70.50	30.4	24.9	19.8
KSPlatC E6-VIIz-VIIa'-VIIIz ENT80	M	L	338	66.29	27.32	28.33	18.08
KSPlat2 E8 -IIIR ENT1	M	R	339	70.90	27.1	28	22.5
K-PAS-MO -VIII T' ENT27	F	L	339	68.84	26.78	32.2	20.6
K-PAC Est2 -IIN' Ent2D	M	L	339	72.71	27.35	27	21.3
KSPlatC E6-VIIIz-VIIIa' ENT81	M	R	340	63.80	27.7	26.2	19.8
K-PAS MO -VIII U' ENT48	M	R	340	68.77	26.57	28.07	17.46
KSPlatC E6-VIIIz-VIIIa' ENT84	M	L	340	70.14	26.85	32.84	23.96
K-PAC E1 -III G' Ent1	M	R	340	66.10	28.16	29.15	20.38
KSPlatC E4-VIa ENT57	M	L	341	69.60	28.5	28.8	25.7
KSPlatC E2-VIIa' Ent18a	M	L	341	67.65	24.52	28.86	21.18
K-PAC E1 -III G ENT1	M	L	341	71.05	29.25	30.97	22.64
KSPlatC E6-VIIIz-VIIIa' ENT93A	M	L	342	69.00	27	29.8	19.9
KSPlatC E3-VIIa' Ent32	M	R	342	75.00	46	-	-

Kuelap Individual ID	Sex	Side	Tibial Length (mm)	Tibial Plateau (mm)	Tibial Distal Breadth (mm)	Tibial AP (mm)	Tibial ML (mm)
K-PAS E1 -VI Q' T1ENT1	M	R	342	69.20	29.2	27.46	19.87
K-PAS E1 -VI Q' T1ENT2	M	R	342	70.33	27.79	29.34	25.32
KSSbPlt1 -IIPE9 Ent1	M	L	342	66.90	27.1	27.7	22.7
KSSbPlt1 -IIPE9 Ent1	M	L	342	66.34	24.89	-	-
KSPlatC E2-VIIa' ENT28	M	R	343	73.15	32.11	31.85	20.05
K-TM E40 -IX U Ent2	M	R	343	68.45	28.34	28.4	19.85
K-CE3-E1	M	R	344	68.00	27.8	31.7	22.8
KSPlatC E6-VIIIz-VIIIa' ENT90A	M	R	344	-	29	28.6	24.2
K-PAS E1 -VI Q' T1ENT6	M	L	344	79.67	29.61	29.6	23.74
K-SSbPl II -VII T Ent1	M	L	345	75.80	27.91	27.98	22.47
KSPlatI IVÑ Ent7	M	L	345	70.71	27.38	28.41	21.1
KSSbPlt1 IOE7 Ent1B	M	L	346	76.14	31.94	31.56	19.58
KSPlatI IIIÑ Ent5	M	L	346	68.37	26.26	30.57	22.68
KSSbPlt1 IOE7 Ent1B	M	L	347	65.00	24.7	24	19.2
K-SbPl II -VIII S E1 Ent1a	M	L	348	69.50	28.79	27.9	20.67
K-PAS-MO ENT5 adu2	M	L	348	69.72	30.22	29.96	22.88
KSPlatC E6-VIIIz-VIIIa' ENT86	M	L	348	-	-	-	-
K-PAS E1 -VI Q' T1ENT5	M	L	348.5	68.45	27.34	33.49	18.09
K-PAC Est2 -IIN' Ent5a	M	R	349	76.98	26.37	31.88	22.57
K-PAS-MO -VIII T' ENT30	M	L	349.5	73.25	26.13	32.26	18.97
KSPlatC E2-VIIa ENT23	M	R	350	-	-	-	-
KSTin-IVv Ent10	M	L	350	75.74	25.95	31.61	27.21
K-PAS E1 -V Q' INT ENT1	M	L	351	68.12	30.57	32.34	24.49
KSPlatC E2-VIIa' ENT21	M	R	351	76.70	28.8	28.7	19.4
KSPlatC E2-VIa' ENT12a	M	L	351	69.28	29.01	30.21	23.08
KSPlatC E2-VIIa' ENT21b	M	R	351	-	27.72	30.3	22.66
KCPlatII -IIIÑ Ent1	M	L	352.0	-	27.3	28.8	22.8
KCPlatII -IIIÑ Ent4	M	L	352	-	27.3	28.8	22.8
KSPlatC E6-VIIIz-VIIIa' ENT82	M	R	353	-	30.9	32.2	19.5
K-PAC Est2 -IIN' Ent3a	M	R	353	-	29.84	28.57	22.87
K-PAS-MO -VIII U' ENT77a	M	R	354	71.30	-	32.5	23
K-PAS MO -VIII U' ENT74	M	L	354	73.80	31.8	32.7	22.18
K-SSbPl II -VII T Ent3	M	L	354	76.06	31.38	31.1	20.47
K-PAC Est2 -IIN' Ent3c	M	R	354	70.77	26.9	30.61	22.32
K-PAS-MO -VIII T' ENT18A	M	L	355	74.00	44	-	-
KSSbP1IIIOE4Ent1A	M	R	355	73.95	27.98	32.08	21.75
KSSbP1IIIOE4Ent1A	M	R	356	71.78	27.73	31.29	24.69
KSTIN -IIU Ent12	M	L	357	74.35	30.13	33.31	22.45
K-SbPl II -VIII S E1 Ent1c	M	R	358	-	31.6	33	24
KSTIN -VU Ent2	M	L	359.0	71.80	27.3	32.3	24.0
K-TM E40 -IX U Ent1	M	L	359	70.90	26.7	31.7	22.4
K-PAS MO -VIII T' ENT44	M	R	359	71.80	27.3	32.3	24
KSPlatC E9-VIa' ENT98	M	R	359	80.16	27.02	30.54	22.64
KSPlatC E4-VIa ENT53	M	L	359	-	-	-	-
K-PAS MO -VIII U' ENT47	M	L	360	71.31	29.38	31.11	19.56
K-TM E33 -IX W Ent1	M	L	360	74.82	30.6	31.54	21.3

Kuelap Individual ID	Sex	Side	Tibial Length (mm)	Tibial Plateau (mm)	Tibial Distal Breadth (mm)	Tibial AP (mm)	Tibial ML (mm)
KSPlatC E6-VIIz-VIIa' ENT69	M	L	360	70.50	26.2	30.06	22.5
K-PAS MO -VIII U' ENT48	M	L	362	74.50	30.1	31.4	21.5
K-TM MNO Ent1	M	L	362.5	71.67	29.31	30.46	19.57
K-SbPl II -VIII S E1 Ent1b	M	L	363	-	-	33.1	21.6
K-PAC Est2 -IIN' Ent2G	M	L	363	75.20	29.9	31.5	20.2
K-PAS-MO -VIII T' ENT29	M	L	364	74.78	29.17	29.4	23.15
K-PAS MO -VIII U' ENT67b	M	L	366	73.90	33	29.1	21.8
KSPlatC E3-VIIa ENT34	M	R	367	75.47	30.13	34.05	20.06
KSPlatC E4-VIa ENT51	M	R	367	72.30	29.94	30.93	19.43
KSPlatC E6-VIIIz-VIIIa' ENT92	M	R	368	69.30	29.8	24.9	24.7
KSPlatC E2-VIIz ENT4	F	L	368	69.70	28.2	31.1	25.9
KSPlatC Patio-VIz ENT2A	F	L	368	75.72	32.17	32.82	23
K-PAS MO -VIII U' ENT56	F	L	370	75.94	30.51	32.16	22.47
K-TM E52 -VZ Ent1	F	L	370	71.90	27.93	27.26	23.82
K-PAS MO -VIII U' ENT49b	F	L	371	-	28.52	29.18	22.23
K-PAS-MO -VIII U' ENT68b	F	L	371	70.40	32.39	28.27	23.84
K-PAS MO -VIII U' ENT65b	F	R	371	73.71	28.66	32.63	21.05

APPENDIX E: KUELAP APPENDICULAR DATA – CALCANEUS

Kuelap Individual ID	Sex	Side	Calcaneus Length (mm)	Calcaneus Breadth (mm)
K-SbPlt II E5 -VII T Ent2	F	-	65.2	35.3
K-TM E38 -VIII V Ent1	F	L	73.58	35.5
KSPlatC E4-VIa ENT65	F	L	72.95	36.4
K-PAS MO -VIII U' ENT45	F	L	75.82	36.7
KSSbPlt1 -II P Ent2	F	-	67.7	37.1
K-PAC Est2 -IIN' Ent1c	F	R	62.44	38.7
KCAc1-IIM ENT1	F	L	75.6	38.7
K-PAC Est2 -IIN' Ent1b	F	R	67.95	39.2
K-PAS MO -VIII U' ENT63	F	R	70	39.6
KSSbPlt1 -IO Ent3	F	L	65.3	39.7
KCPlatII -IIIÑ Ent3A	F	L	69.5	39.8
K-PAC Est2 -IIN' Ent1a	F	L	75.6	39.9
KSPlatC E6-VIIIz-VIIIa' ENT85	F	L	72.06	40.1
KSTIN -II U -II V Ent11	F	-	68.7	41.1
K-PAC Est2 -IIN' Ent2A	F	R	66.39	41.4
KSTIN -III T Ent4	F	-	69.7	41.8
KSPlatC E4-VIa ENT57	M	L	60.9	34.1
KSPlatC E2-VIIa' Ent18a	M	L	62.8	34.6
KSTIN -IIU Ent12	M	L	65.5	36
KSSbPlt1 -IOE8 Ent2	M	L	62.4	36.9
KSPlatC E2-VIIz ENT11	M	L	69.2	36.9
KC E4 IVB ENT5a	M	L	64.68	37.13
KSSbPlt1 -IP Ent2	M	-	70.2	37.4
KSTin-IVv Ent10	M	L	67.8	38.8
KSPlatC E2-VIIa' ENT9a	M	L	74.5	39.4
KSPlatC E6-VIIIz-VIIIa' ENT84	M	L	64.2	39.6
KSPlat1 E4 I Ñ Ent3	M	-	71.9	39.9
K-PAC Est2 -IIN' Ent5a	M	L	75.74	40.2
KSPlatC E2-VIa' ENT12a	M	L	69.9	40.5
KSPlat2 E8 -IIIR ENT1	M	R	74.9	40.5
KSPlatC E6-VIIIz-VIIIa' ENT81	M	L	71.2	40.9
K-SbPlt II E6 -VI U Ent1	M	-	76.6	41.2
KSPlatI IIIÑ Ent5	M	L	72.9	41.5
KSPlatC E4-VIa ENT66	M	L	73.6	41.6
KSSbPlt1 -IOE8 Ent2	M	L	77.2	41.6
K-PAS MO -VIII U' ENT48	M	L	71.14	41.79
KSPlatC E2-VIIa' ENT5	M	L	68.9	41.9
K-SbPlt II E6 -VI U Ent2	M	-	78.2	41.9
K-SbPl II -VIII S E1 Ent1b	M	L	73.6	42.5
KSPlatC Patio-VIz ENT1A	M	L	65.37	42.6
KSPlatC E2-VIa' ENT14	M	L	73.9	43.4
K-PAC E1 -III G' Ent1	M	R	72.9	43.5
K-TM E33 -IX W Ent1	M	L	81	43.8
KSTin E1 -VI V M1	M	-	76.9	44.1
K-PAC Est2 -IIN' Ent3a	M	R	77.6	44.9
K-PAS MO -VIII U' ENT47	M	L	76.08	46.04

Kuelap Individual ID	Sex	Side	Calcaneus Length (mm)	Calcaneus Breadth (mm)
K-PAS-MO -VIII T' ENT27	F	L	42	-
K-PAS MO -VIII T' ENT36a	F	R	61	-
K-SE4-E2	F	R	62.29	-
K-PAS MO -VIII U' ENT67d	F	-	62.4	-
K-PAS MO -VIII T' ENT36b	F	-	64	-
K-PAS-MO -VIII T' ENT28b	F	L	64.2	-
K-SSbPl II -VII T Ent2	F	R	65.32	-
K-PAS-MO ENT7 adu	F	-	65.73	-
KSPlatC Patio-VIz ENT1B	F	R	66	-
K-CE4-E1a	F	R	66.5	-
K-PAC Est2 -III Ñ' Ent7m	F	-	67.3	-
KC E4 IVB ENT5b	F	R	67.5	-
K-PAS MO -VIII U' ENT78	F	R	67.6	-
K-PAS MO -VIII U' ENT58	F	R	68	-
K-PAS MO -VIII U' ENT64	F	R	68.72	-
K-PAS MO -VIII U' ENT50	F	R	69.25	-
K-PAS-MO ENT8 adu	F	L	69.5	-
KSPlatI IIIÑ Ent2B	F	R	70	-
K-PAS-MO ENT1 aduA	F	L	70.18	-
K-TM E38 -VIII V Ent1	F	R	70.29	-
K-PAS MO -VIII U' ENT49b	F	L	70.9	-
K-PAC Est2 -III Ñ' Ent7m	F	-	71.7	-
KSPlatI IIIÑ Ent2C	F	L	72	-
KCPlatII -IIIÑ Ent2	F	L	72	-
K-SE6-E1	F	R	72	-
KSPlatC E2-VIIa' ENT30	F	L	73.2	-
KSPlatC E3-VIIa ENT39A	F	L	74.32	-
K-PAS-MO ENT2 aduB	F	L	75.05	-
KSPlatC E1-VIIz ENT101	F	L	75.31	-
K-PAC Est2 -IIN' Ent5b	F	L	75.9	-
KSPlatC Patio-VIz ENT2A	F	L	76.47	-
K-PAS MO -VIII T' ENT35a	F	L	76.56	-
K-PAC Est2 -III Ñ' Ent7A	F	L	77.15	-
KPANTorVIIa Ent7	F	L	77.5	-
K-PAC Est2 -IIN' Ent3b	F	L	78	-
K-TM E52 -VZ Ent1	F	L	78.1	-
KSPlatC E6-VIIz-VIIa'-VIIIz ENT79	F	L	79.69	-
K-PAS MO -VIII U' ENT44	F	L	80.22	-
K-SbPl II -VIII S E1 Ent1c	M	R	43.5	-
K-PAS-MO ENT4A	M	L	67	-
K-SSbPl II -VII T Ent3	M	L	69.2	-
K-PAC E1 -II H' Ent1	M	L	69.2	-
K-PAS-MO ENT1 aduB	M	L	70	-
KSPlatC E2-VIIa' ENT21	M	R	70.02	-
KSPlatC E2-VIIa' ENT21b	M	R	70.09	-
K-PAC Est2 -III Ñ' Ent7F	M	L	71	-
K-PAS-MO ENT7 adu3	M	-	71.01	-

Kuelap Individual ID	Sex	Side	Calcaneus Length (mm)	Calcaneus Breadth (mm)
KSPlatC E2-VIIa ENT23	M	R	71.21	-
K-PAC Est2 -IIN' Ent2B	M	L	71.31	-
K-PAS-MO ENT8 adu	M	L	71.5	-
KSPlatC E2-VIIz ENT15	M	R	72.1	-
KSPlatC E6-VIIIz-VIIIa' ENT88	M	L	72.21	-
KSSbP1IIIOE4Ent1A	M	R	72.42	-
KSPlatC E3-VIIa' ENT35b	M	R	72.5	-
KCPlatII -IIIÑ Ent1	M	R	72.59	-
KSSbPlt1 -IPE8 Ent3	M	R	72.87	-
K-PAC Est2 -IIN' Ent3c	M	R	72.9	-
KSPlatC E6-VIIIz-VIIIa' ENT92	M	R	73	-
K-CE4-E1b	M	R	73.09	-
KSPlatC E2-VIIa' ENT28	M	R	73.26	-
K-SE4-E3	M	R	73.4	-
K-PAS MO -VIII U' ENT49a	M	R	73.5	-
K-SbPl II -VIII S E1 Ent1a	M	L	73.8	-
K-PAS-MO -VIII T' ENT18A	M	L	73.85	-
K-PAS MO -VIII T' ENT35a	M	-	73.85	-
K-PAC E1 -III G ENT1	M	L	74	-
K-SbPltII -VI U Ent1	M	R	74.27	-
KSSbPlt1 IOE7 Ent1B	M	R	74.64	-
K-PAS-MO ENT11	M	L	74.8	-
K-PAC Est2 -IIN' Ent2G	M	L	75	-
KSSbPlt1 IOE7 Ent1B	M	R	75.09	-
K-CE3-E1	M	R	75.17	-
K-SbPltII -VI U Ent2	M	R	75.19	-
K-PAC Est2 -III Ñ' Ent7m	M	-	76	-
K-TM E40 -IX U Ent1	M	L	76.2	-
KSTin-Vv Ent5	M	R	76.49	-
K-PAS-MO ENT5 adu2	M	-	76.78	-
K-PAN AC3 Ent1b	M	L	77	-
KSPlatC E2-VIIa' ENT8a	M	R	77.09	-
K-S-TM E51 -IV A' ENT1b	M	L	77.1	-
KSSbP1IIIOE4Ent1A	M	R	77.53	-
K-SSbPl II -VII T Ent1	M	L	77.6	-
K-PAS E1 -VI Q' T1ENT2	M	R	77.6	-
KSPlatC E3-VIIa ENT34	M	R	78.4	-
K-PAS-MO ENT5 adu2	M	-	78.42	-
K-PAC E1 -III G' Ent1	M	-	78.5	-
K-PAC Est2 -IIN' Ent2D	M	L	78.64	-
KSPlatC E6-VIIz-VIIa' ENT69	M	R	78.8	-
K-PAS-MO ENT7 adu	M	-	78.89	-
KSPlatC E9-VIa' ENT98	M	R	79	-
K-TM E40 -IX U Ent2	M	R	79	-
K-PAC Est2 -IIN' Ent2F	M	R	79	-
KSPlatC E6-VIIIz-VIIIa' ENT82	M	R	80	-
K-PAS E1 -VI Q' T1ENT6	M	L	80.2	-

Kuelap Individual ID	Sex	Side	Calcaneus Length (mm)	Calcaneus Breadth (mm)
KSPlatC E2-VIIa'-VIa' ENT6	M	R	80.24	-
K-PAS-MO -VIII T' ENT31	M	L	80.45	-
KSPlatC E3-VIIa' ENT36	M	R	80.5	-
KSPlatC E3-VIIa' Ent32	M	R	82	-
KSSbPlt1 -IPE8 Ent3	M	R	82.61	-
K-PAS E1 -V Q' INT ENT1	M	L	84.2	-

APPENDIX F: LA PETACA APPENDICULAR DATA

La Petaca Individual ID	Side	Humeral Length (mm)	Humeral Head (mm)	Humeral Breadth (mm)	Humeral AP (mm)	Humeral ML (mm)	Logit (Length & Head)	Sex	Logit (Length & Breadth	Sex
77	L	248	37.3	36.6	15.3	16.6	-4.83798	F	-4.90756	F
30	L	263	35.1	36.6	16.1	18.1	-5.34106	F	-3.70906	F
234	R	264	37.6	38.5	16.8	17.8	-3.53146	F	-2.81425	F
949	R	267	33.54	36.13	16.17	17.54	-6.15304	F	-3.59104	F
130	R	268	34.6	38.7	16.6	18.4	-5.34626	F	-2.40887	F
950	L	275	36.35	36.07	15.33	18.07	-3.64736	F	-2.97758	F
76	R	281	38	40.7	20.2	17.8	-2.0867	F	-0.51237	F
132	L	288	37.7	36	16.7	18.5	-1.81542	F	-1.9689	F
1114	R	288	36.83	39.8	17.49	17.05	-2.42129	F	-0.33908	F
1193	R	290	38.7	41.95	16.87	17.91	-0.98182	F	0.742855	M
131	R	291	40.4	40.75	20.1	20.5	0.27066	M	0.308075	M
133	L	297	42.1	41	18	18.3	1.86614	M	0.8947	M
1179	R	302	45.84	43.47	20.37	20.59	4.813676	M	2.353583	M
32	R	303	43.3	42.4	8.4	20.5	3.11342	M	1.97456	M
1145	L	305	45.88	47.2	22.04	17.91	5.047332	M	4.19308	M
902	R	306	41.4	43.1	20	19.5	1.99606	M	2.51449	M
1078	R	318	45.88	48.55	21.92	22.88	5.939132	M	5.810795	M
78	L	322	44.7	-	19.4	20	5.39178	M	-	-
33	R	325	44.7	45.4	21.3	23.5	5.59758	M	5.01906	M

La Petaca Individual ID	Side	Femoral Length 1 (mm)	Femoral Head (mm)	Femoral Breadth (mm)	Femoral AP (mm)	Femoral ML (mm)	Logit	Sex	OLS Regression Stature
587	R	347	37.8	-	23.3	20.6	-1.8976	F	132.3
646	R	350	37.5	59.1	22.2	21.4	-1.7584	F	133.3
86	R	353	35.9	57	22.6	24.7	-1.6192	F	134.3
4	R	355	39.4	-	22.8	21.7	-1.5264	F	134.9
217	L	367	41.5	62.9	23.3	19.9	-0.9696	F	138.9
1091	R	372	37.97	62.54	23.5	22.01	-0.7376	F	140.5
216	L	374	34.7	59.5	22.6	20.8	-0.6448	F	141.2
262	L	374	40.3	-	23.3	23.1	-0.6448	F	141.2
3	R	375	39.4	-	23.4	23.4	-0.5984	F	141.5
828	L	376	40.4	64.6	23.3	23.9	-0.552	F	141.8
211	R	380	42.7	65.3	32	24.3	-0.3664	F	143.1
676	L	380	42.6	65.8	27.2	23.4	-0.3664	F	143.1
827	L	380	37.3	59.7	25.8	22.7	-0.3664	F	143.1
391	L	392	40.7	61.6	39.8	25.1	0.1904	M	147.1
1177	R	392	45.09	72.57	28.19	24.66	0.1904	M	147.1
1208	R	394	41.46	66.99	26	24.45	0.2832	M	147.7
219	L	395	40.9	65.1	24.1	24.1	0.3296	M	148.0
218	L	401	40.8	65.6	27.5	24.4	0.608	M	150.0
127	R	410	42.3	71	30	23.6	1.0256	M	153.0
259	R	413	41.5	71.3	25.8	24.8	1.1648	M	153.9
492	R	413	46.9	73.1	30.2	27.5	1.1648	M	153.9
89	R	416	42.6	71.1	27.2	25.8	1.304	M	154.9
92	L	417	43.7	75	8.8	26.7	1.3504	M	155.3
91	L	424	42.6	-	30.4	26.8	1.6752	M	157.6
1097	L	427	46.22	73.71	28.91	25.18	1.8144	M	158.5
220	L	431	45.3	-	30.2	24.7	2.0000	M	159.8
1139	L	433	49.3	78.5	28.2	26.59	2.0928	M	160.5

La Petaca Individual ID	Side	Tibial Length CLT (mm)	Tibial Plateau (mm)	Tibial Distal Breadth (mm)	Tibial AP (mm)	Tibial ML (mm)	Logit	Sex	OLS Regression Stature
634	R	282	61.4	28	25.3	19.9	-2.5017	F	135.3
96	L	287	53.9	26.9	25.6	17.7	-2.1877	F	137.1
98	L	290	-	24.4	21.5	17.2	-1.9993	F	138.1
8	R	292	-	-	27.3	16.8	-1.8737	F	138.8
833	L	300	62.4	25.6	25.4	17.8	-1.3713	F	141.7
222	L	301	62.8	23.3	24.8	19.8	-1.3085	F	142.0
635	R	302	56.9	24.1	23	19.7	-1.2457	F	142.4
733	L	304	68.6	26.6	28	23	-1.1201	F	143.1
397	L	310		23.4	24.4	17.8	-0.7433	F	145.2
1093	R	310	65.18	22.76	24.75	22.09	-0.7433	F	145.2
223	L	315	61.8	21.9	26.8	18.6	-0.4293	F	147.0
1176	R	316	68.02	25.32	26.67	22.21	-0.3665	F	147.3
125	L	320	66.5	25.5	26.7	18.9	-0.1153	F	148.7
599	R	321	64.3	27.8	24.9	22.7	-0.0525	F	149.1
9	R	325	-	-	30.9	21.9	0.1987	M	150.5
489	L	326	68.7	28.5	26.8	23.4	0.2615	M	150.8
1180	R	327	73.29	26.62	27.26	26.65	0.3243	M	151.2
1026	R	328	68.54	28.16	26.73	22.48	0.3871	M	151.5
1175	L	329	70.93	28.88	30.5	22.13	0.4499	M	151.9
1209	R	330	63.05	27.61	30.45	19.09	0.5127	M	152.2
639	L	340	63.8	27.7	26.2	19.8	1.1407	M	155.8
123	R	341	69.6	28.5	28.8	25.7	1.2035	M	156.1
263	L	344	68	27.8	31.7	22.8	1.3919	M	157.2
1140	L	345	75.8	27.91	27.98	22.47	1.4547	M	157.5
395	L	353	-	30.9	32.2	19.5	1.9571	M	160.4
1115	L	353	-	29.84	28.57	22.87	1.9571	M	160.4
17	L	354	71.3	-	32.5	23	2.0199	M	160.7
99	R	354	73.8	31.8	32.7	22.18	2.0199	M	160.7
6	R	363	-	-	33.1	21.6	2.5851	M	163.9
1091	R	372	37.97	62.54	23.5	22.01	3.1503	M	167.1

La Petaca Individual ID	Side	Calcaneus Length (mm)	Clacaneus Breadth (mm)	OLS Regression Stature
682	L	60.9	34.1	140.9
178A	R	62.4	36.9	142.6
1011	L	62.8	34.6	143.1
881	L	64.2	39.6	144.7
1090	R	64.68	37.13	145.3
943	L	65.37	-	146.1
175A	L	65.5	36	146.2
54	R	67.8	38.8	148.9
482	L	68.9	41.9	150.2
681B	-	69.2	36.9	150.5
681A	R	69.9	40.5	151.3
1165	R	71.14	41.79	152.8
880	R	71.2	40.9	152.9
942	R	72.21	-	154.0
177	R	72.9	41.5	154.8
837	L	73.6	41.6	155.6
558	R	73.9	43.4	156.0
557	L	74.5	39.4	156.7
1112	L	76.08	46.04	158.5
176	R	77.2	41.6	159.8
175B	-	-	37.6	-
178C	-	-	35.4	-
178B	-	-	36	-

APPENDIX G: KUELAP FULLY STATURE DATA

#	Kuelap Individual ID	Method Completeness	Condition	Sex	Age Cat.	Age Range	Mean Age
1	K-SbPlt II E6 -VI U Ent 1	75%	Fair	M	YA	18-23	21
2	K-SbPlt II E6 -VI U Ent 2	100%	Good	M	MA	35-44	40
3	K-SbPlt II E5 -VII T Ent 2	100%	Good	F	MA	35-39	37
4	K-TM E38 -VIII V Ent 1	100%	Fair	F	MA	35-44	40
5	K-TM E33 -IX W Ent 1	100%	Fair	M	MA	40-49	45
6	K-PAC E2 -II N' Ent 3A	100%	Good	M	YA	25-34	30
7	K-PAC E2 -II N' Ent 3B	90%	Good	F	MA	30-39	35
8	K-SbPlt II E1 -VIII S Ent 1B	90%	Fair	M	MA	30-39	35
9	K-PAC E2 -II N' Ent 1C	75%	Fair	F	MA	35-44	40
10	K-PAC E2 -II N' Ent 1A	100%	Good	F	YA	30-34	32
11	K-PAC E2 -II N' Ent 1B	100%	Good	F	MA	35-44	40
12	K-PAC E1 -III G' Ent 1	90%	Fair	M	MA	30-39	37
13	K-PAS MO -VIII U' Ent 63	75%	Fair	F	MA	40-44	42
14	K-PAS MO -VIII U' Ent 45	75%	Fair	F	YA	30-34	32
15	KSPlatC E4 -VI a' Ent 57	100%	Good	M	MA	40-49	45
16	KSPlatC E6 -VII Z -VII a' Ent 84	75%	Fair	M	MA	30-39	35
17	KSPlatC E6 -VII Z -VII a' Ent 85	100%	Fair	F	OA	50-60	55
18	KSPlat1 E4 I Ñ Ent3	90%	Good	M	OA	45-60	50
19	KSSbPlt1 -II P Ent 2	90%	Fair	F	OA	50-60	55
20	KSPlatC E6 -VII Z -VII a' Ent 81	75%	Good	M	YA	25-34	30
21	KCAC1n E1 Ent 1	90%	Good	F	YA	20-24	22
22	KSPlatC E6 -VII Z -VII a' Ent 80	75%	Fair	M	YA	30-39	35
23	KSPlatC E4 -VI a' Ent 65	90%	Good	F	YA	23-27	25
24	KSTIN -II U -II V Ent 11	100%	Poor	F	MA	40-49	45
25	KSTIN -II U Ent 12	100%	Poor	M	MA	40-49	45
26	KSTIN -III T Ent 4	100%	Fair	F	YA	30-34	32
27	KSPlatC E4 -VI a' Ent 66a	90%	Fair	M	MA	45-49	47
28	KCPlatII -III Ñ Ent 3A	100%	Good	F	MA	35-44	40
29	KSPlatC E2 -VII a' Ent 14	90%	Fair	M	MA	35-44	40
30	KSPlatC PatLib -VI Z Ent 1a	75%	Fair	M	YA	19-23	21
31	KSSbPlt1 -I P Ent 2	100%	Fair	M	YA	18-20	19
32	KSSbPlt1 -I O Ent 3	90%	Fair	F	MA	30-44	37
33	KSTin E1 -VI V M1	100%	Good	M	MA	35-45	40
34	KSSPlat2 E8 Ent 1	100%	Fair	M	MA	35-39	37
35	K-PAC E2 -IIN' Ent 2A	75%	Good	F	MA	40-49	45
36	K-PAC E2 -IIN' Ent 5A	90%	Fair	M	YA	30-34	32

#	Kuelap Individual ID	Cranial Height	C2	C3	C4	C5	C6	C7	C-Height *
1	K-SbPlt II E6 -VI U Ent 1	139	36.1	12.7	11.4	11.3	11.8	12.7	96.0
2	K-SbPlt II E6 -VI U Ent 2	136	36.5	13.2	12.8	12.6	12.3	14.7	102.1
3	K-SbPlt II E5 -VII T Ent 2	129	32.0	11.9	11.2	10.9	10.4	11.2	87.6
4	K-TM E38 -VIII V Ent 1	99	33.7	10.4	10.8	11.3	10.8	12.4	89.4
5	K-TM E33 -IX W Ent 1	133	34.3	15.8	13.8	14.2	13.7	15.4	107.2
6	K-PAC E2 -II N' Ent 3A	138	35.6	13.2	12.7	13.6	13.9	15.8	104.8
7	K-PAC E2 -II N' Ent 3B	128	34.4	11.5	10.6	11.5	10.3	11.7	90.0
8	K-SbPlt II E1 -VIII S Ent 1B	144	37.4	13.6	11.8	12.0	14.5	15.7	105.0
9	K-PAC E2 -II N' Ent 1C	133	37.3	-	-	-	10.3	12.6	-
10	K-PAC E2 -II N' Ent 1A	127	32.8	9.6	10.3	11.4	10.4	11.8	86.3
11	K-PAC E2 -II N' Ent 1B	139	32.7	11.0	11.3	11.9	10.7	11.5	89.1
12	K-PAC E1 -III G' Ent 1	148	37.9	12.2	12.2	12.1	12.4	14.0	100.8
13	K-PAS MO -VIII U' Ent 63	131	-	-	-	11.0	11.0	13.4	-
14	K-PAS MO -VIII U' Ent 45	133	33.1	9.9	11.1	11.8	10.6	11.6	88.1
15	KSPlatC E4 -VI a' Ent 57	141	-	53.7	12.2	13.1	12.3	14.2	105.5
16	KSPlatC E6 -VII Z -VII a' Ent 84	136	34.9	12.5	13.6	12.2	12.5	15.3	101.0
17	KSPlatC E6 -VII Z -VII a' Ent 85	130	33.1	10.5	10.6	9.6	10.3	12.3	86.4
18	KSPlat1 E4 I Ñ Ent3	130	34.2	12.2	12.7	10.9	13.0	15.6	98.6
19	KSSbPlt1 -II P Ent 2	131	32.7	10.2	10.3	10.1	9.7	11.5	84.5
20	KSPlatC E6 -VII Z -VII a' Ent 81	144	35.2	-	12.5	-	-	15.1	-
21	KCAC1n E1 Ent 1	131	33.6	11.1	10.7	10.3	10.8	13.3	89.8
22	KSPlatC E6 -VII Z -VII a' Ent 80	138	39.0	15.1	15.1	14.8	14.1	15.9	114.0
23	KSPlatC E4 -VI a' Ent 65	131	34.7	12.6	11.5	11.7	11.7	12.0	94.2
24	KSTIN -II U -II V Ent 11	140	33.8	10.6	11.5	10.9	9.9	11.6	88.3
25	KSTIN -II U Ent 12	136	-	50.1	12.3	20.5	28.6	15.5	127.0
26	KSTIN -III T Ent 4	134	32.6	11.8	11.1	11.8	10.2	11.7	89.2
27	KSPlatC E4 -VI a' Ent 66a	130	34.7	11.8	8.8	10.4	11.2	12.5	89.4
28	KCPlatII -III Ñ Ent 3A	135	37.7	12.3	12.1	12.4	12.3	14.5	101.3
29	KSPlatC E2 -VII a' Ent 14	137	40.1	-	-	13.3	13.6	15.6	-
30	KSPlatC PatLib -VI Z Ent 1a	140	37.1	12.5	11.8	11.5	14.9	15.1	102.9
31	KSSbPlt1 -I P Ent 2	133	37.2	12.1	11.3	10.5	11.8	13.6	96.5
32	KSSbPlt1 -I O Ent 3	138	31.2	11.0	9.3	9.2	10.6	12.8	84.1
33	KSTin E1 -VI V M1	135	37.8	12.6	13.7	12.2	12.9	14.4	103.6
34	KSSPlat2 E8 Ent 1	133	33.9	12.9	12.0	11.9	12.6	14.1	97.4
35	K-PAC E2 -IIN' Ent 2A	127	35.9	11.4	10.7	10.7	12.9	12.9	94.5
36	K-PAC E2 -IIN' Ent 5A	141	34.9	12.4	12.0	12.2	11.9	14.6	98.0

Red = Estimated using methods proposed by Auerbach (2011); Green = Approximate measurement of damaged element; * If blank, estimated complete vertebral height using Auerbach (2011)

#	Kuelap Individual ID	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T-Height *
1	K-SbPlt II E6 -VI U Ent 1	15.7	17.3	19.5	-	-	-	-	-	22.1	22.1	23.9	24.6	-
2	K-SbPlt II E6 -VI U Ent 2	16.3	16.1	17.4	16.7	16.8	18.3	18.7	18.7	19.4	19.4	20.7	21.8	220.3
3	K-SbPlt II E5 -VII T Ent 2	14.3	15.5	15.8	15.4	15.5	16.3	16.6	17.5	18.5	18.7	19.2	19.9	203.2
4	K-TM E38 -VIII V Ent 1	13.4	16.3	16.3	16.2	17.7	17.1	16.4	18.2	19.4	20.2	20.3	22.0	213.5
5	K-TM E33 -IX W Ent 1	17.1	18.8	19.1	21.2	18.9	20.0	20.6	21.9	21.7	22.7	20.8	22.7	245.5
6	K-PAC E2 -II N' Ent 3A	15.4	18.4	18.9	18.6	16.5	20.6	20.3	21.6	23.4	24.2	23.2	25.5	246.6
7	K-PAC E2 -II N' Ent 3B	13.6	15.8	16.3	16.8	17.3	17.1	16.9	17.6	19.1	19.5	19.9	22.4	212.3
8	K-SbPlt II E1 -VIII S Ent 1B	15.9	18.6	17.1	18.2	19.1	18.9	19.8	19.1	20.6	19.9	21.2	21.2	229.6
9	K-PAC E2 -II N' Ent 1C	14.0	16.1	16.3	16.6	18.3	18.6	18.7	19.3	-	-	19.9	21.9	-
10	K-PAC E2 -II N' Ent 1A	13.6	14.9	15.8	14.8	15.5	16.0	16.6	17.3	18.3	18.3	18.9	21.7	201.7
11	K-PAC E2 -II N' Ent 1B	17.3	16.3	16.8	16.7	17.6	17.8	18.5	19.0	19.9	19.8	19.5	21.8	221.0
12	K-PAC E1 -III G' Ent 1	15.5	16.4	17.5	18.5	17.6	18.6	19.5	19.4	20.7	21.0	20.3	21.5	226.4
13	K-PAS MO -VIII U' Ent 63	15.3	16.3	16.0	16.2	16.4	17.3	17.2	15.9	20.0	20.1	20.2	20.3	211.2
14	K-PAS MO -VIII U' Ent 45	13.9	14.3	15.6	15.8	15.9	16.0	18.4	19.0	19.8	20.3	20.6	22.4	212.0
15	KSPlatC E4 -VI a' Ent 57	15.3	16.5	17.5	16.9	18.3	18.5	18.7	18.9	19.3	20.5	21.4	22.0	223.8
16	KSPlatC E6 -VII Z -VII a' Ent 84	16.2	17.1	16.6	17.1	17.3	17.4	18.0	18.1	17.7	19.7	20.6	22.8	218.6
17	KSPlatC E6 -VII Z -VII a' Ent 85	13.4	14.9	15.7	15.6	16.8	15.2	12.6	17.9	17.9	18.7	18.9	21.9	199.5
18	KSPlat1 E4 I Ñ Ent3	16.8	18.0	18.2	18.7	10.2	-	-	16.3	18.5	20.9	26.2	25.2	-
19	KSSbPlt1 -II P Ent 2	12.8	14.4	14.3	14.8	15.2	14.8	15.8	16.7	17.4	18.1	18.7	20.6	193.5
20	KSPlatC E6 -VII Z -VII a' Ent 81	15.8	16.4	-	-	-	-	18.5	-	-	21.1	22.5	24.1	-
21	KCAC1n E1 Ent 1	15.9	15.9	15.6	17.0	17.4	18.3	18.7	19.5	19.4	18.8	20.9	22.8	220.2
22	KSPlatC E6 -VII Z -VII a' Ent 80	17.7	19.1	18.7	18.5	20.6	18.7	20.2	20.7	21.6	22.7	23.8	25.1	247.4
23	KSPlatC E4 -VI a' Ent 65	13.2	15.1	15.3	17.3	16.7	17.4	18.1	19.1	19.6	20.5	21.2	23.2	216.7
24	KSTIN -II U -II V Ent 11	13.7	15.7	17.0	17.4	16.2	17.2	18.2	17.6	19.4	19.3	19.4	21.5	212.6
25	KSTIN -II U Ent 12	16.5	17.5	17.5	18.1	17.8	17.8	18.4	19.1	20.9	21.6	21.6	23.3	230.1
26	KSTIN -III T Ent 4	14.1	16.3	16.8	17.3	18.5	18.2	18.7	19.7	21.1	21.8	22.0	24.1	228.6
27	KSPlatC E4 -VI a' Ent 66a	13.5	15.8	16.3	16.2	16.6	16.8	17.9	17.4	18.6	19.3	19.9	19.3	207.5
28	KCPlatII -III Ñ Ent 3A	16.6	17.9	17.4	17.5	19.3	18.7	19.3	20.3	20.1	22.1	22.4	23.8	235.4
29	KSPlatC E2 -VII a' Ent 14	15.4	16.5	16.2	16.4	18.1	18.6	18.4	19.7	20.4	22.4	22.9	23.0	228.0
30	KSPlatC PatLib -VI Z Ent 1a	15.2	-	15.8	-	-	-	-	-	-	22.2	23.4	23.3	-
31	KSSbPlt1 -I P Ent 2	15.5	16.3	17.6	17.6	18.5	19.2	21.6	21.1	22.3	22.3	22.3	22.3	236.6
32	KSSbPlt1 -I O Ent 3	15.1	16.6	16.5	17.3	17.2	18.5	18.5	20.0	20.8	21.2	21.6	21.4	224.7
33	KSTin E1 -VI V M1	17.1	15.6	17.7	17.8	19.1	20.8	20.9	21.2	21.7	23.3	23.5	25.8	244.5
34	KSSPlat2 E8 Ent 1	15.8	16.2	17.2	18.2	18.3	18.3	18.2	19.8	20.2	20.8	21.9	21.6	226.5
35	K-PAC E2 -IIN' Ent 2A	14.0	15	15.4	15.2	15.9	17.2	17.3	18.1	18.9	19.6	20.4	20.7	207.6
36	K-PAC E2 -IIN' Ent 5A	16.3	17.8	17.9	18.6	18.9	19.2	20.5	20.4	20.7	21.1	21.4	24.7	237.5

Red = Estimated using methods proposed by Auerbach (2011); Green = Approximate measurement of damaged element; * If blank, estimated complete vertebral height using Auerbach (2011)

#	Kuelap Individual ID	L1	L2	L3	L4	L5	L-Height	Vert Height	S1
1	K-SbPlt II E6 -VI U Ent 1	28.7	30.5	32.2	31.5	31.8	154.7	522.6	30.7
2	K-SbPlt II E6 -VI U Ent 2	23.9	25.0	26.7	26.1	27.1	128.8	451.2	31.7
3	K-SbPlt II E5 -VII T Ent 2	23.7	23.8	25.2	24.7	24.5	121.9	412.7	24.9
4	K-TM E38 -VIII V Ent 1	23.7	24.6	26.7	26.8	27.5	129.3	432.2	28.1
5	K-TM E33 -IX W Ent 1	27.9	28.3	28.9	28.4	31.3	144.8	497.5	31.7
6	K-PAC E2 -II N' Ent 3A	26.9	28.5	27.8	28.5	30.5	142.2	493.6	35.1
7	K-PAC E2 -II N' Ent 3B	23.0	25.0	23.9	25.4	25.4	122.7	425.0	28.6
8	K-SbPlt II E1 -VIII S Ent 1B	25.2	25.8	26.7	28.3	26.4	132.4	467.0	29.2
9	K-PAC E2 -II N' Ent 1C	23.9	24.9	26.2	25.4	26.0	126.4	448.0	24.3
10	K-PAC E2 -II N' Ent 1A	22.7	23.8	23.8	25.4	24.5	120.2	408.2	26.5
11	K-PAC E2 -II N' Ent 1B	23.9	24.8	25.9	26.2	26.7	127.5	437.6	30.2
12	K-PAC E1 -III G' Ent 1	23.5	23.1	23.9	24.8	25.9	121.2	448.4	29.2
13	K-PAS MO -VIII U' Ent 63	23.5	24.5	24.1	24.2	25.8	122.1	423.0	32.7
14	K-PAS MO -VIII U' Ent 45	24.1	25.0	25.9	26.3	26.6	127.9	430.2	27.7
15	KSPlatC E4 -VI a' Ent 57	22.7	23.2	-	-	89.0	134.9	464.2	27.4
16	KSPlatC E6 -VII Z -VII a' Ent 84	24.1	24.3	24.9	25.5	26.8	125.6	445.2	29.7
17	KSPlatC E6 -VII Z -VII a' Ent 85	21.4	21.9	24.2	23.5	24.3	115.3	401.2	28.6
18	KSPlat1 E4 I Ñ Ent3	25.9	25.6	26.7	27.4	26.6	132.2	463.4	31.4
19	KSSbPlt1 -II P Ent 2	21.2	22.6	22.6	22.8	24.1	113.3	391.3	28.5
20	KSPlatC E6 -VII Z -VII a' Ent 81	25.9	25.9	26.3	27.8	28.2	134.1	468.4	32.3
21	KCAC1n E1 Ent 1	24.1	25.1	26.0	27.4	27.3	129.9	439.9	26.6
22	KSPlatC E6 -VII Z -VII a' Ent 80	27.6	26.8	26.8	28.7	28.6	138.5	499.8	59.8
23	KSPlatC E4 -VI a' Ent 65	25.6	26.4	27.2	27.4	26.5	133.1	444.0	26.1
24	KSTIN -II U -II V Ent 11	19.7	21.9	24.6	22.7	22.8	111.7	412.6	27.8
25	KSTIN -II U Ent 12	21.2	26.0	26.2	25.2	24.8	123.4	480.5	27.5
26	KSTIN -III T Ent 4	26.1	26.7	26.9	27.7	26.4	133.8	451.6	31.5
27	KSPlatC E4 -VI a' Ent 66a	21.8	23.3	25.3	25.1	24.9	120.4	417.3	30.4
28	KCPlatII -III Ñ Ent 3A	26.2	26.5	26.3	28.4	28.7	136.1	472.8	31.3
29	KSPlatC E2 -VII a' Ent 14	26.2	25.4	26.5	28.2	28.6	134.9	458.2	31.3
30	KSPlatC PatLib -VI Z Ent 1a	26.2	26.8	26.3	26.5	27.5	133.3	466.3	28.1
31	KSSbPlt1 -I P Ent 2	23.3	24.8	25.3	28.2	27.0	128.6	461.7	26.8
32	KSSbPlt1 -I O Ent 3	22.4	23.0	27.2	27.1	27.5	127.2	436.1	29.2
33	KSTin E1 -VI V M1	25.0	27.2	24.8	28.6	29.0	134.6	482.7	34.5
34	KSSPlat2 E8 Ent 1	23.9	24.1	25.1	26.5	26.2	125.8	449.7	30.9
35	K-PAC E2 -IIN' Ent 2A	23.3	24.6	26.8	26.8	28.4	129.9	432.0	29.3
36	K-PAC E2 -IIN' Ent 5A	25.3	24.9	25.4	25.6	27.1	128.3	463.8	30.6

Red = Estimated using methods proposed by Auerbach (2011); Green = Approximate measurement of damaged element

#	Kuelap Individual ID	Fem (Bicond.)	Tibia (CLT)	Talus-Calc.	Fem (Max)	Calc. L.	Calc. B.	Skeletal Height*	Fully Stature*	95% C.I.
1	K-SbPlt II E6 -VI U Ent 1	407	333	67	410	76.6	41.2	149.9	162.4	± 4.5 cm
2	K-SbPlt II E6 -VI U Ent 2	406	335	69	412	78.2	41.9	142.9	154.6	± 4.5 cm
3	K-SbPlt II E5 -VII T Ent 2	370	300	57	376	65.2	35.3	129.4	141.0	± 4.5 cm
4	K-TM E38 -VIII V Ent 1	393	321	65	396	68.0	35.5	133.8	145.4	± 4.5 cm
5	K-TM E33 -IX W Ent 1	455	380	72	461	81.2	43.8	156.9	168.5	± 4.5 cm
6	K-PAC E2 -II N' Ent 3A	446	363	66	448	76.1	44.9	154.2	166.4	± 4.5 cm
7	K-PAC E2 -II N' Ent 3B	387	313	56	-	63.2	-	133.7	145.6	± 4.5 cm
8	K-SbPlt II E1 -VIII S Ent 1B	420	344	66	424	70.8	42.5	147.0	158.9	± 4.5 cm
9	K-PAC E2 -II N' Ent 1C	393	320	59	397	68.3	38.7	137.8	149.4	± 4.5 cm
10	K-PAC E2 -II N' Ent 1A	383	308	57	387	65.8	39.9	131.0	142.9	± 4.5 cm
11	K-PAC E2 -II N' Ent 1B	379	302	62	384	64.5	39.2	135.0	146.6	± 4.5 cm
12	K-PAC E1 -III G' Ent 1	423	344	70	425	79.9	43.5	146.3	158.1	± 4.5 cm
13	K-PAS MO -VIII U' Ent 63	416	326	56	421	70.1	39.6	138.5	150.0	± 4.5 cm
14	K-PAS MO -VIII U' Ent 45	394	320	55	-	64.6	36.7	136.0	148.0	± 4.5 cm
15	KSPlatC E4 -VI a' Ent 57	411	349	68	419	77.7	41.5	146.1	157.6	± 4.5 cm
16	KSPlatC E6 -VII Z -VII a' Ent 84	418	348	64	419	72.9	38.8	144.1	156.0	± 4.5 cm
17	KSPlatC E6 -VII Z -VII a' Ent 85	385	314	64	388	68.0	40.1	132.3	143.2	± 4.5 cm
18	KSPlat1 E4 I Ñ Ent3	399	328	67	401	71.9	39.9	141.9	153.1	± 4.5 cm
19	KSSbPlt1 -II P Ent 2	382	321	61	383	67.7	37.1	131.5	142.4	± 4.5 cm
20	KSPlatC E6 -VII Z -VII a' Ent 81	418	347	66	421	76.4	41.4	147.6	159.7	± 4.5 cm
21	KCAC1n E1 Ent 1	396	318	57	400	68.1	38.7	136.8	149.2	± 4.5 cm
22	KSPlatC E6 -VII Z -VII a' Ent 80	423	348	-	-	-	-	146.9	158.8	± 4.5 cm
23	KSPlatC E4 -VI a' Ent 65	385	313	59	390	66.7	36.4	135.8	148.1	± 4.5 cm
24	KSTIN -II U -II V Ent 11	384	316	63	389	68.7	41.1	134.3	145.7	± 4.5 cm
25	KSTIN -II U Ent 12	444	373	66	446	77.7	45.2	152.7	164.3	± 4.5 cm
26	KSTIN -III T Ent 4	411	332	66	415	69.7	41.8	142.6	154.6	± 4.5 cm
27	KSPlatC E4 -VI a' Ent 66a	425	342	67	432	73.4	37.0	141.2	152.5	± 4.5 cm
28	KCPlatII -III Ñ Ent 3A	419	337	68	421	71.7	39.8	146.3	158.0	± 4.5 cm
29	KSPlatC E2 -VII a' Ent 14	390	321	-	392	75.2	41.5	133.8	145.4	± 4.5 cm
30	KSPlatC PatLib -VI Z Ent 1a	424	336	66	427	73.1	42.6	146.0	158.6	± 4.5 cm
31	KSSbPlt1 -I P Ent 2	411	331	62	413	70.2	37.4	142.6	155.1	± 4.5 cm
32	KSSbPlt1 -I O Ent 3	419	346	61	423	65.3	39.7	142.9	154.7	± 4.5 cm
33	KSTin E1 -VI V M1	431	355	72	433	76.9	44.1	151.0	162.8	± 4.5 cm
34	KSSPlat2 E8 Ent 1	415	346	69	419	74.6	40.5	144.4	156.2	± 4.5 cm
35	K-PAC E2 -IIN' Ent 2A	400	334	60	402	68.9	41.4	138.2	149.7	± 4.5 cm
36	K-PAC E2 -IIN' Ent 5A	412	349	66	422	76.0	40.2	146.2	158.3	± 4.5 cm

* = Value in cm; Red = Estimated using methods proposed by Auerbach (2011); Green = Approximate measurement of damaged element.

APPENDIX H: LINEAR REGRESSION STATURE ESTIMATES OF KUELAP SAMPLE

#	Kuelap Individual ID	Sex	Genoves XLF	Genoves CLT	del Angel and Cisneros XLF	del Angel and Cisneros CLT	Pomeroy and Stock XLF	Pomeroy and Stock BLF	Pomeroy and Stock CLT
1	K-SbPlt II E5 -VII T Ent 2	F	147.1	145.4	144.6	142.9	145.8	145.3	141.7
2	K-TM E38 -VIII V Ent 1	F	152.3	151.1	149.7	148.6	151.0	151.3	147.6
3	K-PAC E2 -II N' Ent 3B	F	152.9	148.9	150.3	146.4	151.6	149.7	145.4
4	K-PAC E2 -II N' Ent 1C	F	152.6	150.9	150.0	148.4	151.3	151.3	147.4
5	K-PAC E2 -II N' Ent 1A	F	150.0	147.6	147.4	145.1	148.7	148.7	144.0
6	K-PAC E2 -II N' Ent 1B	F	149.2	145.9	146.6	143.4	147.9	147.7	142.3
7	K-PAS MO -VIII U' Ent 63	F	158.8	152.5	156.2	150.0	157.5	157.3	149.0
8	K-PAS MO -VIII U' Ent 45	F	152.9	150.8	150.3	148.3	151.6	151.6	147.3
9	KSPlatC E6 -VII Z -VII a' Ent 85	F	150.2	149.2	147.7	146.7	148.9	149.2	145.7
10	KSSbPlt1 -II P Ent 2	F	148.9	151.1	146.4	148.6	147.7	148.5	147.6
11	KCAC1n E1 Ent 1	F	153.3	150.3	150.8	147.8	152.1	152.1	146.8
12	KSPlatC E4 -VI a' Ent 65	F	150.8	148.9	148.2	146.4	149.5	149.2	145.4
13	KSTIN -II U -II V Ent 11	F	150.5	149.7	147.9	147.2	149.2	149.0	146.2
14	KSTIN -III T Ent 4	F	157.2	154.1	154.7	151.6	155.9	156.0	150.7
15	KCPlatII -III Ñ Ent 3A	F	158.8	155.4	156.2	153.0	157.5	158.1	152.1
16	KSSbPlt1 -I O Ent 3	F	159.3	157.9	156.7	155.4	158.0	158.1	154.6
17	K-PAC E2 -IIN' Ent 2A	F	153.9	154.6	151.3	152.1	152.6	153.1	151.3
18	K-SbPlt II E6 -VI U Ent 1	M	159.0	158.9	156.6	151.7	157.1	157.3	153.0
19	K-SbPlt II E6 -VI U Ent 2	M	159.5	159.4	157.1	152.4	157.6	157.0	153.8
20	K-TM E33 -IX W Ent 1	M	170.6	168.2	168.2	164.7	171.0	170.3	167.2
21	K-PAC E2 -II N' Ent 3A	M	167.6	164.9	165.2	160.0	167.5	167.9	162.1
22	K-SbPlt II E1 -VIII S Ent 1B	M	162.2	161.2	159.8	154.8	160.9	160.8	156.4
23	K-PAC E1 -III G' Ent 1	M	162.4	161.2	160.0	154.9	161.2	161.6	156.5
24	KSPlatC E4 -VI a' Ent 57	M	161.1	162.2	158.7	156.2	159.5	158.4	157.9
25	KSPlatC E6 -VII Z -VII a' Ent 84	M	161.1	162.0	158.7	155.9	159.5	160.3	157.6
26	KSPlat1 E4 I Ñ Ent3	M	157.0	158.0	154.6	150.5	154.6	155.1	151.7
27	KSPlatC E6 -VII Z -VII a' Ent 81	M	161.5	161.8	159.1	155.7	160.1	160.3	157.3
28	KSPlatC E6 -VII Z -VII a' Ent 80	M	162.1	162.0	159.7	155.9	160.8	161.6	157.6
29	KSTIN -II U Ent 12	M	167.2	166.9	164.8	162.7	166.9	167.3	165.1
30	KSPlatC E4 -VI a' Ent 66a	M	164.0	160.8	161.6	154.3	163.1	162.2	155.9
31	KSPlatC E2 -VII a' Ent 14	M	155.0	156.7	152.6	148.6	152.1	152.7	149.6
32	KSPlatC PatLib -VI Z Ent 1a	M	162.9	159.6	160.5	152.7	161.7	161.9	154.1
33	KSSbPlt1 -I P Ent 2	M	159.7	158.6	157.3	151.3	157.9	158.4	152.6
34	KSTin E1 -VI V M1	M	164.2	163.3	161.8	157.9	163.4	163.8	159.7
35	KSSPlat2 E8 Ent 1	M	161.1	161.6	158.7	155.4	159.5	159.5	157.1
36	K-PAC E2 -IIN' Ent 5A	M	161.8	162.2	159.3	156.2	160.3	158.7	157.9

#	Kuelap Individual ID	Sex	Self-Regres. XLF	Self-Regres. BLF	Self-Regres. XLF + BLF	Self-Regres. CLT	Self-Regres. XLC	Self-Regres. MBC	Self-Regres. XLC + MBC
1	K-SbPlt II E5 -VII T Ent 2	F	141.8	141.0	141.4	141.7	145.9	143.5	143.4
2	K-TM E38 -VIII V Ent 1	F	148.4	148.6	148.5	149.1	149.1	143.9	145.9
3	K-PAC E2 -II N' Ent 3B	F	149.1	146.5	149.1	146.2	143.6	150.6	148.6
4	K-PAC E2 -II N' Ent 1C	F	148.7	148.6	148.7	148.8	149.5	150.3	149.1
5	K-PAC E2 -II N' Ent 1A	F	145.4	145.3	145.4	144.5	146.6	152.7	148.2
6	K-PAC E2 -II N' Ent 1B	F	144.4	143.9	144.2	142.4	145.1	151.3	146.4
7	K-PAS MO -VIII U' Ent 63	F	156.6	156.2	156.4	150.8	151.6	152.1	151.5
8	K-PAS MO -VIII U' Ent 45	F	149.1	148.9	149.1	148.7	145.2	146.3	144.2
9	KSPlatC E6 -VII Z -VII a' Ent 85	F	145.7	145.9	145.9	146.6	149.1	153.1	150.2
10	KSSbPlt1 -II P Ent 2	F	144.1	144.9	144.7	149.1	148.8	147.1	147.2
11	KCAC1n E1 Ent 1	F	149.7	149.6	149.7	148.0	149.3	150.3	149.0
12	KSPlatC E4 -VI a' Ent 65	F	146.4	145.9	146.2	146.2	147.6	145.7	145.7
13	KSTIN -II U -II V Ent 11	F	146.1	145.6	145.8	147.3	150.0	155.1	151.7
14	KSTIN -III T Ent 4	F	154.6	154.5	154.6	153.0	151.1	156.5	153.2
15	KCPlatII -III Ñ Ent 3A	F	156.6	157.2	157.0	154.7	153.4	152.5	153.0
16	KSSbPlt1 -I O Ent 3	F	157.2	157.2	157.2	157.9	146.0	152.3	147.6
17	K-PAC E2 -IIN' Ent 2A	F	150.3	150.9	150.7	153.7	150.2	155.7	152.1
18	K-SbPlt II E6 -VI U Ent 1	M	153.0	153.2	153.2	153.1	159.1	155.3	158.3
19	K-SbPlt II E6 -VI U Ent 2	M	153.6	152.9	153.2	154.0	161.0	156.7	160.3
20	K-TM E33 -IX W Ent 1	M	169.7	169.1	169.3	169.9	164.5	160.5	164.6
21	K-PAC E2 -II N' Ent 3A	M	165.4	166.1	165.8	163.9	158.5	162.8	161.3
22	K-SbPlt II E1 -VIII S Ent 1B	M	157.6	157.5	157.5	157.2	152.4	157.9	154.7
23	K-PAC E1 -III G' Ent 1	M	157.9	158.5	158.3	157.2	162.9	159.9	163.2
24	KSPlatC E4 -VI a' Ent 57	M	155.9	154.5	155.1	158.9	160.4	155.9	159.5
25	KSPlatC E6 -VII Z -VII a' Ent 84	M	155.9	156.8	156.5	158.6	154.8	150.5	153.0
26	KSPlat1 E4 I Ñ Ent3	M	150.0	150.5	150.4	151.5	153.7	152.7	153.2
27	KSPlatC E6 -VII Z -VII a' Ent 81	M	156.6	156.8	156.8	158.2	158.9	155.7	158.4
28	KSPlatC E6 -VII Z -VII a' Ent 80	M	157.4	158.5	157.4	158.6	157.8	156.0	157.7
29	KSTIN -II U Ent 12	M	164.8	165.4	165.2	167.4	160.4	163.4	163.0
30	KSPlatC E4 -VI a' Ent 66a	M	160.2	159.1	159.6	156.5	155.4	146.9	151.8
31	KSPlatC E2 -VII a' Ent 14	M	147.1	147.6	147.4	149.1	157.5	155.9	157.5
32	KSPlatC PatLib -VI Z Ent 1a	M	158.5	158.8	158.7	154.4	155.1	158.1	156.7
33	KSSbPlt1 -I P Ent 2	M	153.9	154.5	154.3	152.6	151.7	147.7	149.5
34	KSTin E1 -VI V M1	M	160.5	161.1	160.9	161.1	159.5	161.1	161.3
35	KSSPlat2 E8 Ent 1	M	155.9	155.8	155.9	157.9	156.8	153.9	156.0
36	K-PAC E2 -IIN' Ent 5A	M	156.9	154.8	155.6	158.9	158.4	153.3	156.9

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