

**MORPHOLOGICAL VARIATION OF THE PROXIMAL FEMUR IN
SELECTED SKELETAL REMAINS**

A Thesis by

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I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts with a major in Anthropology.

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DEDICATION

To My Family and Friends

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ABSTRACT

The purpose of this thesis is to examine the structural variation of the proximal femur in human skeletal samples. The goal was to investigate and further describe the morphology of the proximal femur through quantitative observation. Subsets of measurements were used to calculate platymeric indices, which demonstrate the presence or absence of platymeria in a population. Metric analyses of the femur were also used to study size and shape differences in populations for indications of sexual dimorphism or asymmetry. Finally, selected platymeric index measurements were observed for intraobserver error, to test the validity of the measures and how well the researcher performed them.

Data examining the morphology of the proximal femur were collected from a prehistoric Albanian site, a late 18th century Albanian site, and from a documented modern, industrial skeletal collection. In this study, platymeria was identified in the proximal femur in the two pre-industrial Albanian samples for both sexes and side. The results varied when compared to the industrial collection, which was eurymeric in both sexes and side. The proximal femoral differences in side and sex of the pre-industrial and industrial remains shed light on biomechanical investigations. Overall, results conclude that the use of platymeric indices allowed the researcher to successfully distinguish variations in the proximal femur among three populations.

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CHAPTER 1

INTRODUCTION

Purpose and Thesis Design

The purpose of this study is to examine the morphology of the proximal femur within and among groups using a biomechanical approach. The main goals are to (1) observe the variation between the proximal diaphyseal shape among two temporally-distinct pre-industrial Albanian samples, (2) compare/contrast the two Albanian samples against a documented industrial sample, (3) discern if any sexual dimorphism exists, (3) observe whether differences in left and right femur indicate asymmetry, (4) examine the various measurements used and their respective indices on how well they predict the shape of the proximal femur, (5) and the extent of intraobserver errors in proximal femoral measurements.

It is hypothesized that a set of variables that include measures of femora from three groups will show size and shape differences between pre-industrial and industrial populations, males and females, and right and left sides. Additionally, it is hypothesized that the differences in morphology reflect the amount of mechanical load placed on the bone. Finally, what measurements are used to quantify the shape of the proximal femur and where they are taken is crucial for correctly distinguishing shape differences among populations.

The applications of this study are pertinent to estimating ancestry, determining sexual dimorphism in a population, and the overall amount of stress being placed on the proximal femur. The broader applications of such a study lie in

the increasing understanding of morphological variability in past and present human populations.

The present study addresses the question of estimating ancestry and sexual dimorphism in forensic and archaeological investigation of skeletal remains using measurements from the proximal femur. Prior research has focused on population, sex, and side differences of the femur. This study will focus on the validity of measurements used to estimate ancestry, within and between population variation, sexual dimorphism in the femur, and femoral shape in three groups: a pre-industrial late Bronze-Early Iron Age Albanian sample, a pre-industrial late 18th century Albanian sample, and an industrial sample comprised of American Whites. In addition, the researcher will examine the effect of mechanical loading variation due to subsistence strategy and divisions of labor in order to understand the influences that the environment and biomechanics have on the shape of the proximal femur.

Research in Morphological Variation

Research questions often focus on what influences affect the morphology of the diaphysis of the proximal femur. The proximal diaphyseal shape of the femur is assessed just below the position of the lesser trochanter. The process of measuring proximal diaphyseal shape can be done either qualitatively or quantitatively. Researchers have shown that the proximal femoral diaphysis below the lesser trochanter is seen as oval or flattened in cross sections of American Indian skeletons and rounded in American Whites (Gilbert and Gill 1990). The visual method has yielded satisfactory results when comparing two disparate populations, but the precision and replicability in a quantitative approach is needed to compare/contrast

further populations. The quantitative assessment utilizes standardized measurements taken inferior to the lesser trochanter. To quantify the diaphysis of the proximal femur the platymeric index (PI) is used.

The range of shape variation found in platymeric indices allows biological anthropologists to group individuals into three population categories (platymeric, eurymeric, and stenomic). Recently, forensic anthropologists have applied the PI index to distinguish between prehistoric and historic Native American femora and femora from American Whites and Blacks (Gill and Gilbert 1990).

Researchers recognize that the shape of the proximal femur is likely influenced by genetics, while there are also bodies of data that demonstrate interdependence between diaphyseal size and shape related to subsistence strategy and the environment. Further, it is known that during life, bone is continuously modifying itself so that the diameter, shape, and thickness of bone reflect the manner and degree of biomechanical forces (Wescott 2005). As a result, the shape of the proximal femur may reflect increased mechanical stress placed on the bone due to daily activity patterns more than genetics. Recent studies are trying to examine whether platymeric indices better reflect ancestry or environmental plasticity.

The employment of proximal femur shape to assess ancestry can be useful, but there are criticisms of this type of research. Criticisms result because numerous cultural, environmental, and biological factors can affect the shape of the femur and are difficult to control for in biomechanical studies of archaeological populations, such as the pre-industrial Albanian samples used in this study. However, the criticisms focus on studies that compare archaeological populations with different economic, biological, and cultural patterns. This study

focuses on two archaeological populations within the same Albanian geographical region and similar subsistence strategies are practiced, which may help to control for the controversial factors.

CHAPTER 2

BACKGROUND OF THE FEMUR

The Femur Briefly

The femur is known for being the largest and longest bone in the human skeleton. This bone supports all of the weight of the body during such motions as standing, waking and running. The structural function of the femur requires that it endure these mechanical loads, by changing its shape, size, and mass. (Wescott 2001). Basically, the femur bone can be divided into three major parts, which include: the proximal portion (head and neck), the shaft, and the distal end (lower condyles). The architecture of each of the femur parts change to meet the functional demands placed on it during daily activity patterns (Frost 1987).

The femur bone, along with being the largest and longest, is also the most measured and reported bone of the human skeleton. Biological and forensic anthropologists for its great role in estimating sex and stature study the femur. The femur bone is also studied extensively for its contribution to assessing ancestry when craniofacial features are absent. Researchers have discovered differences between human populations in femoral size, anterior shaft curvature, torsion, and subtrochanteric shape in various populations.

The femur is additionally studied, because it separates modern humans greatly from primates and early hominids, such that the evolution of the femur and its changing shape and structure has allowed increased capacity for human habitual biped locomotion and balance. Overall, femoral remains are some of the best-

preserved bones in the archaeological record and the clues they provide to biological anthropologists regarding past and present people are many.

Anatomy of the Femur

The research for this study focuses on the proximal part of the femur, which is acted upon by the pelvic bones and associated muscles. The key properties of the proximal end of the femur consist of the head, neck, two trochanters (greater and lesser), and the muscles bearing upon these elements. Ultimately, these features along with their associated muscles will be analyzed to understand how they can shape the proximal femur.

Growth of the Femur

In beginning to understand the shape of the proximal femur and its features, a basic understanding of how the femur is formed is needed. Fundamentally, the ossification of the femur starts from a primary center for the shaft and four epiphyseal centers around the eighth intrauterine week (Bass 1995). Before birth the ossification of the distal epiphysis begins, which is usually the only secondary center to appear before birth (Bass 1995). The head appears as a nucleus around one year of age. The appearance of the greater trochanter shows around the fourth year with the lesser trochanter not showing until around the eleventh year (Bass 1995). The epiphyses begin to unite first at the proximal end. The head and greater and lesser trochanter epiphyses unite between the ages of fourteen and nineteen (Bass 1995).

Features of the Proximal Femur

The adult, fully developed, femur bone articulates with the os coxa superiorly and the tibia and patella inferiorly. The two human femora are widely separated in the body by the pelvis. In erect posture, the femur inclines downward, slightly backwards, and medially so that the distal ends of the femur become closer together towards the knees (Bass 1995). The purpose for the gradual downward and inward inclination is to bring the knee-joint near the line of gravity of the body, thus increasing balanced bipedal mobility (Gray 1918).

Since the femur is involved with the basic human activities it can be assumed these could have some effect on the shape of the proximal femur. Specifically, the actions that involve the proximal end of the femur are those that act with the hip, which include medial and lateral rotation, abduction, adduction, flexion, and extension (Aiello and Dean 1990). In the proceeding paragraphs, the features of the head, neck, two trochanters (greater and lesser), and the muscles acting upon the proximal femur will be examined and how their role in determining its morphology will be described.

The head, which makes up about two-thirds of a sphere, articulates with the acetabulum of the pelvis. This ball-and-socket joint created by this articulation allows for greater mobility at the hip joint. The head is directed superiorly, medially and a little anterior (Gray 1918). There is a pit located on the head of the femur, called the fovea capitis, for the attachment of the ligament of the head, ligamentum teres (White 2000). The ligamentum teres contains within it the blood vessels needed to feed the femoral head (Aiello and Dean 1990). The ligamentum teres is known for its thickness and variable strength.

Distally, the head of the femur is attached to the shaft by way of the neck. The neck is a flattened process of bone pyramidal in shape. The anterior surface of the neck contains many vascular foramina. The posterior surface on the other hand is smooth, more concave, and is broader than the anterior side (White 2000). The superior portion of the neck, which terminates at the greater trochanter, is thick and short and perforated by large foramina. The inferior surface of the neck is long, narrow and curves posteriorly to terminate at the lesser trochanter (White 2000).

The neck varies in length and obliquity during different life phases and according to sex. In infancy, the neck is at its widest point becoming lessened during growth (Aiello and Dean 1990). At puberty, the neck forms a gentle curve from the shaft axis (Gray 1918). In the adult male, the neck forms an angle to the shaft of approximately one hundred and thirty degrees (Gray 1918). While in the female, where the hips are more widely separated, the neck will form nearly a right angle with the shaft (Gray 1918). The neck angle-shaft arrangement also affects the degree of medial inclination, resulting in the female having a greater degree of inclination than males due to the greater breadth of the pelvis.

Lateral to the head and neck is where the greater trochanter is located. The greater trochanter is a bony protuberance that provides an area of insertion for the gluteus medius and minimus (White 2000). The gluteus medius is an important muscle for the abduction of the pelvis in humans. The gluteus medius also rotates the thigh: the anterior fibers rotate the thigh medially while the posterior fibers rotate laterally (Aiello and Dean 1990). In humans, the gluteus medius covers the gluteus minimus. The gluteus medius originates on the ilium's lateral side and inserts onto the greater trochanter. The gluteus minimus arises under the gluteus medius

between the middle and anterior curved lines of the ilium and inserts medially to it on the greater trochanter (Aiello and Dean 1990).

The position of the two gluteal muscles over the lateral side of the hip joint and their functions of abductors of the thigh is unique for human bipedal locomotion (Aiello and Dean 1990). These muscles also help to stabilize the pelvis, such that when weight is taken off one lower extremity, these small gluteal muscles on the opposite side will contract. The action of shifting weight by the gluteus medius and minimus contracting prevents the pelvis from collapsing toward the unsupported side of the body (Aiello and Dean 1990).

Another muscle attaching to the greater trochanter is the obturator externus muscle. The obturator externus is a lateral rotator of the thigh. The obturator externus arises from the obturator membrane, which covers the obturator foramen and surrounding bone (Gray 1918). This muscle then runs laterally, posteriorly and inferior to the hip joint wrapping around the posterior part of the neck and eventually inserting on the greater trochanter (Gray 1918). The tumultuous journey of this muscle is a direct result of the habitually extended human thigh. When the hip joint is flexed, then the obturator externus muscle will run in a direct line from its point of origin to its insertion (Aiello and Dean 1990).

On the posterior aspect of the proximal femur lies the lesser trochanter. The lesser trochanter provides an area for the attachment of the iliopsoas muscle, the main flexor of the hip (Aiello and Dean 1990). The iliopsoas is comprised of two muscles, the psoas major and the iliacus. The psoas major originates on the T12-L5 vertebrae and inserts onto the lesser trochanter (White 2000). The iliacus originates from the iliac fossa and the lateral part of the proximal sacrum and inserts onto the

tendon of the psoas major (Aiello and Dean 1990). The iliacus is also inserted into the shaft below the lesser trochanter between the vastus medialis that attaches anteriorly and the pectineus posteriorly (Gray 1918).

As stated earlier, the greater and lesser trochanters are prominent processes of bone that provide leverage for the muscles that attach to them. The muscles that act upon these two processes function to rotate the thigh on its axis. The two trochanters are connected to each other by way of the intertrochanteric crest. There exists a bony bump on the proximal portion of this crest called the quadrate tubercle. The quadrate tubercle is the insertion site for the quadratus femoris, a lateral rotator of the thigh (Aiello and Dean 1990).

The anterior portion of the proximal femur is also important for providing attachment areas for muscles. One of these landmarks is the intertrochanteric line, which serves as a boundary line for the neck and shaft. The intertrochanteric line is the important attachment site for the iliofemoral ligament (White 2000). The intertrochanteric line extends obliquely from an anterior projection point of the greater trochanter, called the femoral tubercle, across the anterior proximal femur to where it becomes continuous with the spiral line inferiorly (Aiello and Dean 1990). The spiral line then spirals to the posterior surface of the femur where it joins the linea aspera. The spiral line marks the attachment site for the fascia covering the vastus medialis, an extensor of the knee (Aiello and Dean 1990).

The shaft of the femur begins just inferior to the lesser trochanter on the posterior surface of the proximal end. The beginning of the shaft is also level with the upper part of the spiral line found on the anterior surface of the femur. Once the spiral line passes to the posterior side of the femur and towards the shaft it joins

the linea aspera. The linea aspera is a projecting ridge located posteriorly and runs along the shaft. This structure is used as an attachment site for the muscles needed for the human upright posture (Aiello and Dean 1990).

Another feature found just inferior to the lesser trochanter is the pectineal line. The pectineal line is directly lateral to the spiral line (Aiello and Dean 1990). The line is about three centimeters long for the attachment of the pectineus muscle (Aiello and Dean 1990). The pectineus is the most superior of the adductors of the thigh. This muscle originates on the pubis bone and inserts onto the proximal half of the pectineal line (Aiello and Dean 1990).

Lateral to the pectineal line is the gluteal ridge, or hypotrochanteric line. The gluteal ridge is a visibly roughened line that marks the insertion of the gluteus maximus. The gluteus maximus is an important extensor of the hip and is also a lateral rotator of the thigh (Gray 1918). This muscle is the largest in the human buttock. It originates from the posterior portion of the iliac crest, the sacrum, the superior part of the coccyx, and the sacrotuberous ligament (Gray 1918). The gluteus maximus inserts on the gluteal ridge of the femur along with the iliotibial tract (Aiello and Dean 1990). This muscle is inactive and relaxed during normal walking movements. It comes into action during activities where more power is needed such as running and climbing. The gluteus maximus functions also to balance and control the lower body during activities involving the upper limbs such as digging and carrying (Marzke et al. 1998).

The area inferior to the lesser trochanter and on the posterior side of the femur is highly variable. There are times where the gluteal ridge is found combined with a linear depression (the hypotrochanteric fossa) on its outer border. Sometimes

this linear depression occurs on its own without the gluteal ridge (Aiello and Dean 1990). In some cases there is a distinct third trochanter present. This third trochanter is also referred to as the trochanter tertius and the gluteal tuberosity (Aiello and Dean). This bony knob if present will be located lateral to the lesser trochanter. The third trochanter can occur by itself or in combination with the gluteal ridge, the hypotrochanteric fossa or both (Aiello and Dean 1990).

Mechanical Stress on the Femur

Knowledge of these bony landmarks and muscles described above are useful for studies on how they can ultimately shape the shaft of the femur. Activity patterns are dependent upon the muscles enacting them. These muscles in turn are anatomically regular in origination, insertion, and rotation abilities, thus their resulting load or stress on the femur are in consistent patterns. The primary loading forces on bone are tension, compression, bending, and torsion (Larsen 1997). Bending, which involves compression on the concave surface and tension on the convex surface, is a significance force on the femur (Larsen 1997). The diaphysis of the femur can be subject to considerable bending stress, because of the positions of its articulations and major muscle attachments (Preuschoft 1970, Currey 1986, Bertram and Bieuener 1988, Swartz and Bieuener 1992).

In fact, anteroposterior expansion of the femur midshaft is shown to correlate with elevated levels of mobility in response to increased cortical bone strain from anteroposterior diaphyseal bending (Ruff, 2000). Studies have shown that during running or climbing, the hamstrings and quadriceps muscles contract, causing anteroposterior bending on the femoral midshaft (Morrison, 1968, 1969). The

activity-related mechanical loads result in the modeling of the femur shaft to be one that is more anterioroposterior elongated and also mediolaterally wider (Morrison 1968). Using the same logic, it is assumed that the proximal femur shaft inferior to the lesser trochanter would be subjected to the same stresses as the midshaft and would change shape in similar patterns.

It remains unclear whether the femoral diaphysis shape is affected by normal patterns of locomotive contractions, major muscles acting upon its surface, or axial loading of the diaphyses. Yet, as demonstrated through the research on the muscles acting upon the proximal surface on the femur, they all have a potentially significant role in shaping the femur. Most importantly, the femur shaft can change shape with added use of these muscles during high activity patterns and the resulting shape is anterioroposteriorly elongated along with a widened mediolateral diameter. This final shape is what biological anthropologists study using platymeric indices.

Comparative Anatomy of the Femur

When considering the evolution of the femur biological anthropologists rely on a comparative anatomy approach to provide a knowledgeable base for research. In order to interpret how humans are unique regarding the femur bone, a list of specific differences between humans and non-human primates is needed. Furthermore, modern human femoral characteristics must be differentiated from our hominid ancestors. Evolution of the human femur must be studied with a broad comparative perspective in order to understand its cause and effect relationships. The specific changes to the human proximal femur from its primate ancestors and from the early hominids will be discussed.

The femur bone is one that separates humans greatly from other primates. The distinct structural changes to the human femur are associated with the evolution of human bipedalism and an erect posture. Thus, the changes between the proximal femur of the ape and that of the human is in terms of shape, positioning, and functioning. The combined effects of these changes have separated the two dramatically. In order to consider the full human adaptive success, both the similarities and differences to other non-human primates must be taken into account.

A major difference between humans and primates are how the femora are positioned inferior to the pelvis, because of the fact that humans are habitually bipedal. The physical structure of humans reveals the adaptations for upright walking as the normal mode of locomotion. Bipedalism is adaptive so that the hindlimbs are exclusively involved in locomotion and the forelimbs freed for manipulation leading to a fully developed precision grip (Bilsborough 1992). Therefore, the postcranial skeleton provides support for the body and also acts as a lever system for muscle action.

There are a number of differences between humans and non-human primates throughout the postcranial skeleton that allow humans to stand bipedally. Requirements of bipedal locomotion is the ability to stand upright and the center of gravity must be directly over the rectangular area formed by the supporting feet. In adult humans, the center of gravity is located in the mid-line just anterior to the second lumbar vertebra (Aiello and Dean 1990). While standing at rest, a line passing through this point and perpendicular to the ground bisects the body horizontally. This line provides a position for minimal muscle activity needed in order to sustain the standing erect posture (Aiello and Dean 1990). The strong

ligaments acting and assisting the postcranial skeleton help stabilize the body. For example, the iliofemoral ligament, which attaches the femur head to the ilium and passes over the hip joint, ensures that the trunk of the body does not fall backwards at the hip joint (Aiello and Dean). While, the cruciate ligaments in the knee keep the upper body and thighs from falling forwards at the hip joint (Aiello and Dean 1990).

The human femur is considerably longer than the ape femur in relation to body weight and in relation to skeletal measures. The relative lengths of long bones reflect the different requirements of weight transfer between humans and non-human primate skeletons (Aiello and Dean 1990). These differences in lengths can be found in all the long bones of the upper and lower skeleton, since modern humans have long lower limbs in respect to the upper limbs. The relative differences in bone lengths are also reflected in the differences in body weight distribution. For example, the relatively short-legged apes carry less weight in their lower limbs and more weight in their upper limbs than does the human who carries more weight in their longer lower limbs (Aiello and Dean 1990). Overall, humans have longer lower limbs in relation to upper limbs because they carry their body weight in the lower limbs.

Other morphological differences in the femur reflect this disparity in weight transfer. The first is the mediolateral curvature of the femoral shaft. In humans, the mediolateral curvature is laterally convex in the proximal part of the femur above the midline of the shaft (McHenry 1978). In apes, the femora are laterally convex throughout the whole length of the femur (McHenry 1978). Secondly, the cortical thickness in the femoral shaft is different between the two. Humans have greater cortical thickness on the lateral side than the medial side at midshaft (McHenry

1978). This fact reflects the human weight transfer along the lateral aspect of the shaft beginning slightly superior to the midshaft. On the other hand, apes have a relatively equal distribution of cortical thickness.

Differences in Femoral Features of Apes and Humans

Once the differences in locomotion and its influence on the total femoral structure have been identified, a closer examination of the proximal femur can be made. Distinguishing a proximal femur requires the use of descriptive qualitative characteristics, such as: differences in size, shape, and the absence or presence of certain features. The features of the proximal femur that will be studied include: the femoral head, the femoral neck, the neck-shaft angle, the intertrochanteric line, the greater and lesser trochanters, the gluteal tuberosity, the hypotrochanteric fossa, and the obturator externus groove.

The structure of the head and neck of the femur is important to the division between human and ape. In relation to body size, the femoral head of a human is much larger than the head of the ape femur (Trinkaus et al. 1994). This is consistent with the other joint surfaces, because humans carry a greater proportion of body weight in the lower limbs. Another significant difference in the size of the femoral head is that in humans it is allometric, while in apes it is not. Allometry is the relation between the size of an organism and the size of any of its parts (Trinkaus et al. 1994). Allometry is evident in that larger bodied modern humans have femoral heads that are much bigger than smaller bodied modern humans. The ape on the other hand does not have an allometric cross-section of the neck of the femur like humans do. Christopher Ruff in 1988, suggested that the allometry found in the

femoral head and cross-section of the femoral neck in humans indicates an increase in body size increases the weight loading on this area, which would not be the case for quadrupedal apes.

The position of the head on the neck is another proximal femoral distinction between the two. In humans, the articular surface of the head sits squarely on the neck or extends anteriorly, whereas in chimpanzees the head extends posteriorly on the neck. Apes also have a much shorter femoral neck than that of modern humans. (Aiello and Dean 1990). In 1972, Jenkins announced this could be indicative of the different mechanics in the hip joint due to locomotion patterns. Humans have a deep and anterolaterally facing acetabulum, while the chimpanzee acetabulum faces laterally and is shallow.

Chimpanzees further differ from humans in that they lack an intertrochanteric line that marks the attachment for the iliofemoral ligament. The iliofemoral ligament is strong in humans, because it maintains the body in an erect position during bipedalism. As stated above, the iliofemoral ligament prevents the hip joint from falling posteriorly. The intertrochanteric line is absent in apes, because the iliofemoral ligament is weak due to the apes movement with a habitually flexed hip.

The cortical bone thickness of the neck is another morphological difference marker between apes and humans. In humans, the cortical bone in the neck is concentrated around the distal half. The proximal half of the neck circumference as a result has very thin cortical bone. The unbalanced cortical distribution is made possible, because humans have smaller gluteal muscles that function as abductors of the hip and pull in line with the neck of the femur. These gluteal muscles reduce the

stress on the superior part of the upper neck reducing the need for thick cortical bone in this area. Apes on the other hand have no muscles that pull in line with the femoral neck; therefore thick cortical bone is needed around the entire neck circumference (Aiello and Dean 1990). The above skeletal evidence increases the significance the action of musculature has on bone morphology.

The greater trochanter in the two species differs in shape as well. When compared to humans, the ape's greater trochanter is placed higher in relation to the superior border of the neck. The greater trochanter of the ape also lacks the lateral projection that is characteristic of humans (Aiello and Dean 1990). Moreover, the ape has a much deeper trochanteric fossa, which is situated on the medial surface of the greater trochanter. The trochanteric fossa is the site for the insertion for the obturator externus muscle that is one of the lateral rotators of the thigh at the hip (Aiello and Dean 1990). Muscles needed for locomotion are notable, because they affect the overall shape of the proximal femur. On the whole, the relationship between muscle attachment sites and skeletal morphology is significant.

The lesser trochanter in both species is approximately the same absolute size. But, in relation to the overall size of the chimpanzee femur, the lesser trochanter is much larger and more prominent. The larger size reflects the insertion of the psoas muscle, a flexor of the thigh at the hip joint (Aiello and Dean 1990). For example, if the chimpanzee femur was laid flat on its posterior surface the lesser trochanter would hold it up in place, rather than in humans where the posterior surface of the greater trochanter would suspend the femur.

The gluteal tuberosity, or gluteal ridge as it sometimes called, is another distinguishable proximal femur characteristic. The gluteal tuberosity is part of the

upper branch of the linea aspera, where the gluteus maximus is attached. This ridge is recognized in 98.5% of American Caucasian femora samples (Aiello and Dean 1990). In other human populations, this ridge can be absent from 11-13% of the cases (Aiello and Dean 1990). In gorillas, on the other hand, the ridge is absent in 92.2% of adults (Aiello and Dean 1990). It has also been discovered that the gluteal ridge decreases in frequency through the growth period of apes, while in human populations the ridge tends to increase in frequency during growth (Aiello and Dean 1990).

The position of the gluteal tuberosity on the femur can also be a site for a third trochanter. The third trochanter on the proximal femur is an oblong, rounded, or conical area of bone that “occurs variably on, instead of, or above the gluteal ridge” (Hrdlicka 1937). The third trochanter is another attachment site for part of the gluteus maximus muscle. In modern humans, this feature varies from 11.5% found among the Cantonese Chinese to 43.4% of the North American Indians (Aiello and Dean 1990). It is also known that femora that have third trochanters will also appear to be slightly more platymeric than average. Among the great apes, the third trochanter is present in 9%, although it is never found as developed as it is in the human femora (Hrdlicka 1937). In addition, the third trochanter is not found in orangutan or gorilla femora samples (Hrdlicka 1937).

The hypertrochanteric fossa is a further characteristic that is variably found on femora. The hypotrochanteric fossa is an elongated groove that runs laterally to the gluteal ridge on the femur. The fossa is not usually well developed and if it occurs it does so where the gluteal ridge would have appeared (Gray 1918). In the great apes that normally have this fossa it is well defined and is located lower and

more laterally on the shaft than in humans. In humans, the frequency of fossa occurrence is greater in children and juveniles than adults. It develops in the fifth fetal month and then increases in size during the growth period until it begins to decline in adulthood (Aiello and Dean 1990). This regression is the cause of adult remodeling and the reason for bony deposits of the gluteal ridge being laid down, obliterating the fossa (Aiello and Dean 1990).

The obturator externus groove is an additional feature on the femur positioned on the left of the posterior surface of the neck of the femur. The connecting tendon of the obturator externus muscle forms the obturator externus groove (Aiello and Dean 1990). The muscle originates from the body of the pubis, ischiopubic ramus, and obturator. In humans, the fibers of the obturator externus converge into the tendon that passes posterior to the neck of the femur to insert in the trochanteric fossa (Aiello and Dean 1990). As this tendon passes posterior to the neck it can leave a noticeable rounded groove that extends diagonally superiorly to the point of insertion. Since the chimpanzee has a habitually flexed hip posture, the tendon passes in a straight line from its origin on the pelvis to its insertion at the trochanteric fossa (Aiello and Dean 1990). The tendon does not wrap itself around the back of the neck, resulting in no obturator externus groove being there.

Overall, the femoral shaft in general is different between apes and humans. The most noticeable shaft disparity lies in the presence of a well-developed pilaster in humans and the absence of one in apes. The pilaster is beam-like structure that extends down the posterior side of the femoral shaft to support the linea aspera. Its presence varies with the development of the human femur, but occurs in 71% of American Caucasians (Aiello and Dean 1990). The pilaster develops in childhood

and adolescence years, while the linea aspera develops in middle fetal life. Both of these features increase in frequency and expression during adult life. The pilaster is usually absent in African apes even though the linea aspera is present. The appearance of the pilaster in humans and its nonappearance in non-human primates creates shape diversity of femoral mid-shaft cross-sections. For example, humans mid-shaft in cross-section have an anteroposterior diameter that is larger in relation to the transverse diameter than that in apes (Aiello and Dean 1990).

The structural differences between apes and humans regarding the proximal femoral shaft are many. The disparities are indicative of the differences in locomotion, weight bearing, the relative length of the femur, the acting muscles, and variable growth patterns between the two. Comparing features of the proximal femur enables biological anthropologists to distinguish human femora from non-human primates. Using comparative proximal femoral analysis, the same distinctions can be made between modern humans and their early hominid ancestors.

Plasticity in the Femur

Biological anthropologists are aware of bone and its remarkable malleability in adapting to alterations in mechanical loads to which it is subject and to other environmental stimuli. This attribute of bone has been named plasticity. Julius Wolff, a German anatomist, first brought the plastic property of bone to the surface in 1892 (Hughes 1968). Wolff formulated a law that pointed out that there is a relationship between mechanical use and bone structure and it is generally thought that bone shape is related to its functional bone growth as it responds to local mechanical conditions (Roberts 1995). The extent of plasticity can be gauged from

the range of skeletal variability in modern human populations compared to past populations. Any studies of these variations are attempting to understand the macro and microevolution of man.

Human plasticity refers to the ability humans have in changing their biology to respond to stresses in the environment. Gabriel Lasker introduced the term plasticity to the study of human biology in 1969 (Pritchard, 1995). It has lately been used in the sense of its phenotypic response to environment. This concept is a key link in human biology and it provides the rationale for widely disparate studies that aim at understanding biological human variation. Studies on increasing plasticity also aim to characterize the evolution of *Homo sapiens* from its hominid ancestors. The femur bone and its increasing plasticity in the evolution from early hominids to *Homo sapiens* will help in understanding the variables affecting diaphyseal shape.

The Evolution of the Femur

Many of the distinctive skeletal structures of hominids can be interpreted biomechanically, as adaptations to extend the range of movement about a joint or increase the efficiency of muscles involved in these actions. The proportions between *Australopithecines* and *Paranthropines* (the early hominids) proximal femora are different from modern humans and chimpanzees. The two most obvious features that differ among these species are the greater relative length of the femoral neck and a relatively smaller femoral head (Aiello and Dean 1990).

The femoral neck length of the *Paranthropines* is considerably long when compared to modern humans, while those of *Australopithecines* are closer to the modern mean. Neck length might reflect the fact that *Australopithecines* are less

divergent from the pongid pattern than the later *Paranthropines* (Aiello and Dean 1990). The femoral neck cross-section of the *Australopithecines* and the *Paranthropines* are ellipsoid in shape rather than circular like modern humans and apes. The neck cross-section is undoubtedly related to the increased bending movements imposed on the neck by its long neck length (Aiello and Dean 1990). The cortex of the inferior part of the neck is thickened, but shares with humans in that the cortex is thin in the superior part of the neck. The comparable thinning of the cortex in the superior half of the neck may relate to the small gluteal muscles in line with this part of the femoral neck in these hominids and modern humans (Trinkaus and Ruff 1994).

The femoral head size in comparison to femoral length in these early hominids also falls within the modern human range. Nevertheless, when compared to the transverse diameter of the femoral shaft, the diameter of the head falls below the modern mean (Trinkaus and Ruff 1994). This observation might suggest that early hominids had relative femoral head sizes comparable to modern humans, but with more robust femoral shafts. The femoral head of these early hominids also differs in shape. The morphology is hemispherical in shape rather than consisting of about two-thirds of a sphere as it does in modern humans (Aiello and Dean 1990). The *Paranthropines* femoral head sits squarely on the femoral neck as it does on the more robust *Australopithecines*. The location of the femoral head on the more gracile *Australopithecines* in turn compares to the chimpanzee condition, where the articular surface of the head extends onto the posterior surface of the neck (Aiello and Dean). The condition of the femoral head could either suggest a different locomotive pattern for the smaller *Australopithecines* or more favorably reflect sexual dimorphism.

The lateral margin of the greater trochanter in early hominids lacks the distinctive flare or lateral projection found in modern humans. Instead, the lateral margin of the greater trochanter is flush with the lateral margin of the shaft. This difference may reflect the difference in function of the pelvic abductors according to some specialists. Lovejoy et al. believe that the modern lateral flare reduces the bending stress on the long femoral neck (2002). For the early hominids the lack of the flare would permit a reduced neck length explaining its small size (Lovejoy et al. 2002).

As a result of most of the fossil evidence being fragmentary, the total morphology of the femur shaft is not well known of the early hominids. However, the evidence does permit the observation that the shaft is round both at its proximal and mid-shaft ends. This rounded morphology is contrasted to the anteroposteriorly flattened shafts characteristic of the archaic *Homo* group hominids and of African apes. Brothwell (1963:Table 2) provides figures that show variability in the platymeric index among different archaic and modern human groups. Brothwell gives two examples of platymeria existing in the fossil record. The first is Cro-Magnon man with a platymeric index (PI) of 73mm and the other is Neanderthal man with a PI of 77mm (Brothwell 1963). While, in recent *Homo* groups, Brothwell provides that the platymeric index for Turks is 73mm, American Indians 74mm, Andamanese 78mm, Eskimo 81mm, Australians 82mm, and English (17th cent.) 85mm (Bass 1995).

It has also been suggested that the shafts of the *Australopithecines* and *Paranthropines* are more robust than modern humans and the African apes (Aiello and Dean 1990). Although the femur is relatively short in early hominids it lengthens in

relation to the trunk length. The lengthening occurs throughout human evolution until it attains modern human proportions with the onset of *Homo erectus*.

The archaic *Homo* group consists of the fossils belonging to *Homo habilis* and *Homo erectus*. The femora of this group are remarkably consistent in morphology for almost two million years expanding from Africa to Asia to Europe. The morphology includes an anteroposterior flattening of the shaft, a medial convexity of the shaft, a low point of minimum shaft breadth, and a cortex that is thicker on the medial side of the shaft at mid-shaft than on the lateral side like modern humans (Aiello and Dean 1990). This pattern is described for the Lower and Middle Pleistocene hominids by G. Kennedy (1983) and for the Upper Pleistocene by Erik Trinkaus (1976). The pattern regards weight transfer that is distinct from modern humans and the great apes. The load axes in these femora intersects the anatomical axis at the distal end of the femur rather than higher up the shaft as seen in modern humans (Aiello and Dean 1990). Also, the medial convexity curvature of the shaft contrasts markedly with the patterns of lateral convexity found in apes and humans. The medial convexity could reflect a higher activity level that is common in modern human populations.

As seen by the above examples, using the comparative method not only makes distinctions between apes and humans femora, but also between different species of hominids. The comparative method is the best approach in studying the evolution of the proximal femur. The changes seen in the proximal femur are the activity-related consequences of bipedalism and standing with an erect posture, which characterize a modern human. It must be noted that the comparative process used to distinguish between species is not clear-cut and there is always room for

improvement. The biological anthropologist has available the knowledge of human variation and theory to greatly contribute to the question of how the proximal femur has evolved.

CHAPTER 3

BACKGROUND OF RESEARCH ON THE PROXIMAL FEMUR

Morphological Research on the Proximal Femur

This study addresses the question of what influences affect the morphology of the diaphysis of the proximal femur. The proximal diaphyseal shape of the femur is assessed just inferior to the lesser trochanter. The process of measuring proximal diaphyseal shape can be done either qualitatively or quantitatively. The visual (qualitative) method looks for the degree of flatness and ridging in this area of the femur. George W. Gill has used a visual method for more than a decade to distinguish Plains Indian femora from those of Whites. The method Gill employs reveals that the proximal femoral generally tends to be oval or flattened in cross sections of American Indian skeletons and rounded in American Whites (Gilbert and Gill 1990).

The visual method has yielded satisfactory results when comparing two disparate populations, but the precision and replicability in a quantitative approach is needed to compare/contrast further populations. The quantitative assessment utilizes standardized measurements taken at the subtrochanteric location. The first attempt to quantify the visual method was made by Elizabeth Carr, a University of Wyoming student who applied the platymeric index (Bass 1995) to a sample of Northwestern Plains Indians and “frontier” Whites (Gilbert and Gill 1990:98).

To quantify the subtrochanteric region of the femur the platymeric index is used. Femur subtrochanteric shape is quantitatively estimated using the platymeric index (PI). The platymeric index is calculated by dividing the subtrochanteric

anteroposterior diameter by the mediolateral diameter and then multiplying by 100 (Bass 1995). Non-pathological individual shape variation in the PI ranges from 55 to 125mm (Wescott 2005). The range of shape variation allows biological anthropologists to group individuals into three population categories (platymeric, eurymeric, and stenomeric). Individuals who display a PI less than 84.9mm are considered platymeric. Thus, the platymeric shape of the subtrochanteric region would be observed to be more mediolaterally broad. On the otherhand, those individuals with a PI between 85 and 99.9mm are labeled as eurymeric. In the case of eurymeria, the proximal diaphysis displays a round shape. Finally, individuals whose PI index is greater than 100 are organized into a stenomeric group, where the proximal femoral shape is broader anteroposteriorly (Bass 1995).

Gilbert and Gill (1990) conducted a small study extended upon Carr's at the University of Wyoming. The study consisted of measuring the femora of 102 Blacks and 59 Whites and an additional 113 American Indian femora from the prehistoric Smithsonian collection. Using a standard caliper, the measurements of the PI index described by Bass (1995) were taken by these researchers. Bass (1995) describes the anteroposterior and mediolateral subtrochanteric diameters, as taken just inferior to the lesser trochanter of the proximal femur, avoiding the gluteal tuberosity.

The results from this quantitative study yielded similar results to the visual assessment in that American Indians have a flatter cross-section than either Whites or Blacks. Gilbert and Gill (1990) determined that Indians could be distinguished from non-Indians 61% of the time. The researchers also mentioned that there is some hint for genetic control and thus is useful for any time frame. More work was

mentioned that needed to be done on modern populations. Recently, subtrochanteric studies on various populations have been the result of this first quantitative study.

The differences in femur subtrochanteric shape have been noted in the past and recently forensic anthropologists have used the application of the PI index. Gill and colleagues (1990) believe that subtrochanteric can be used to distinguish between prehistoric and historic Native American femora and femora from American Whites and Blacks. The findings of the research conducted by Gill et al. (1990, 1987) show that the mediolateral diameter is generally greater relative to anteroposterior diameter in Native Americans compared to American Whites and Blacks. Therefore, Native American proximal femora are found to be more platymeric than the eurymeric American Whites and Blacks. Recently, Clow (1997) and Voulgaris (1999) discovered that platymeria exists in Polynesians from Easter Island. Gill (2001) relies on this new data to suggest that descendants of East Asian populations are more platymeric than populations stemming from Europe or Africa. Gill further proposes that Asian descendants and their populations are consistently platymeric. The employment of proximal femur shape to assess ancestry can be useful, but there are issues and problems that can arise.

Recently, Daniel Wescott obtained femoral measurements from five groups: Native Americans (n=1659), Polynesians (n=179), Hispanics (n=41), American Blacks (n=320), and American Whites (n=672). The sample of Native Americans used came from the University of Tennessee/Smithsonian Institution postcranial database and included historic and prehistoric remains from the American Great Basin, Great Plains, Southwest, and Texas Gulf Coast. The Polynesian sample of Wescott's study came from Hawaiian skeletons measured by Dr. Charles Snow, and

the Hispanic data were derived from the Forensic Data Base. The American Blacks and American Whites were acquired from the Terry Collection housed at the Smithsonian Natural History Museum (Wescott 2005). Wescott calculated the PI to measure femur shape.

Wescott (2005) found that in general females displayed slightly more platymeria than males, except for American Blacks. Also, the main difference between males and females was size, not shape. Males exhibit larger anteroposterior and mediolateral subtrochanteric diameters, but there is no significant sexual dimorphism in the platymeric indices. He also found that Polynesians and Native Americans are platymeric with relatively short femora, while Blacks and Whites were eurymeric with relatively long femora. Hispanics were found to be intermediate in both femur size and shape.

Wescott (2005) showed that within Native Americans there is geographical variation in the platymeric index (PI). Northern Plains exhibited significant platymeria compared to Native American males from other regions. The PI among females was smaller in the Northern Plains than in the Southwest females. There were no other significant geographical PI differences among males and females.

Significant differences were also found among three different subsistence strategy male groups, with Plains Horticulturalists being the most platymeric. Among females, there was no significant difference in PI between Agriculturalists and Plains Horticulturalists, but the Hunter-Gatherer females exhibited significantly less platymeria than the other two groups (Wescott 2005).

Sexual Dimorphism in the Femur

Issues surrounding subtrochanteric shape revolve around the influence of genetics, mechanical stress, and sex differences all being discussed in research today. According to Wescott (2005) and Ruff (1987), females display more platymeria because of the wider pelvic breadth. The structure of females varies from males because of a greater pelvic width in the ability to bear children. The wider interacetabular distance of females would result in greater mediolateral bending of the subtrochanteric region, causing greater platymeria (Ruff 1987). Within-group variation in the proximal femur, expressed as sexual dimorphism, may also reduce the validity the proximal femur shape has in predicting ancestry (Ruff 1987). Hence, sex differences may reduce the validity in estimating ancestry.

Asymmetry

Systematic directional asymmetry favoring the left side has been reported in the human lower limb, especially the femur (Shultz 1937; Latimer and Lowrance 1965; Ruff and Jones 1981). Many studies assume that the association between behavioral and morphological asymmetry is through mechanically driven bone growth and remodeling (e.g., Steele 2000). Skeletal bilateral asymmetry is used in archaeological samples to infer asymmetry in mechanical loading due to behavior (Mays 2002). Environmental factors can also influence the bilateral asymmetry of the proximal femur.

In this study, comparisons between (presumably) more physically active (pre-industrial) and less physically active (industrial) groups are made, because there is reason to believe active humans have greater asymmetry (Ruff 2000). Auerbach and

Ruff (2006), have demonstrated that there are significantly greater amounts of directional and absolute asymmetry in diaphyseal breadth dimensions than in either length or articular measures ($p < 0.01$). Also, Auerbach and Ruff show a left-bias in lower limb diaphyseal breadths in 29 of their 36 samples over the nine populations, pre-industrial and industrial.

The increased asymmetry in external diaphyseal breadths may be due to a continual subperiosteal expansion of long bone cortices throughout life (Ahlborg et al. 2003). The amounts of asymmetry in diaphyseal breadths within limbs suggest that these regions may be constrained in response to mechanical loading or other environmental factors (Rutherford 2000). There is also greater environmental plasticity of diaphyseal breadths, supported by observations of greater variation in diaphyseal breadth asymmetry between individuals within and among populations (Auerbach and Ruff 2006). Given that increased or decreased mechanical loading effects asymmetry of the diaphyseal breadth, it can be interpreted that variation in behavioral patterns among and within groups can be delineated (Auerbach and Ruff 2006).

It has also been found that reduced asymmetries and sexual dimorphism in asymmetry in industrial groups relative to pre-industrial groups may reflect a reduction in activity level or homogeneity of activity patterns (Ruff 1987). More recent populations have shown diminishing asymmetry and sexual dimorphism in asymmetry, probably reflecting changes in division of labor (Auerbach and Ruff 2006).

Biomechanics

Modeling and remodeling modify the diaphyses of long bones during life resulting in changes in diameter, shape, and thickness of cortical bone that reflect the process and degree of biomechanical forces. Consequently, the diaphyseal shape may reflect increased stress placed on the bone during daily activity and/or physical terrain. This phenomenon suggests that proximal femur shape differences might not be a valid distinction when estimating ancestry, because the shape variation might be affected more by environmental plasticity than genetic diversity.

Intraobserver Error

Subtrochanteric diameters have been found to be error-prone, by Adams and Byrd (2002). Adams and Byrd found as much as 4.3% interobserver in the subtrochanteric mediolateral diameter and 8.5% in anteroposterior diameter (Adams and Byrd 2002). They argue that error results mostly from osteologists being unfamiliar with how far distal to the lesser trochanter the measurement should be taken. Another difficulty for osteologists resides on how closely the anteroposterior and mediolateral orientations should be maintained (Wescott 2005).

Wescott (2005) reports an interobserver error conducted with a colleague in which 1.3% error was found in the mediolateral diameter and 4.7% error found in the anteroposterior diameter. Overall, the anteroposterior diameter percentage of interobserver error was high in Wescott's study.

The ranges of interobserver error question the biological anthropology and forensic validity of subtrochanteric shape differences. Intraobserver errors have not been reported in published PI studies. The percent errors for intraobserver

studies thus have not been defined. It must be noted, that the same problems stated above can occur when an osteologist is confused on where they should take the PI diameters, especially when time has passed between measurement trials. In order to control for these vague definition problems an osteologist must also test their own measurement techniques for accuracy. The test of intraobserver error can add strength in using the platymeric index technique to characterize population variation.

Past research on the proximal femur has described the subtrochanteric shape in many populations. Past research has been instrumental in preparing the research for this study and also for providing samples with which to compare the Albanian remains.

CHAPTER 4

MATERIALS AND METHODS

Samples

Femoral measurements of mature individuals with complete epiphyseal closure were obtained. These measurements consisted of twenty-five in number and were applied to three population skeletal samples: Kamenica, Vithkuq, and Hamann-Todd. Two of these samples are from the pre-industrial sites of Kamenica and Vithkuq, located in southeastern Albania. Both sites existed on a high-elevated terrain, and practiced undeveloped agricultural subsistence strategies where the women in the population were responsible for planting, harvesting and preparing the fields for crops. The major difference between these two populations is the time periods described for each.

The Albanian Archaeology Rescue Unit first excavated Kamenica, a tumulus site in southeastern Albania, in 2000 and again in 2002. The site of Kamenica dates from the very end of the 13th century BC to the mid-sixth century BC. The tumulus has a diameter of more than 40 meters and the height at the center is approximately 3 meters (Amore and Bejko 2001). One-third of the tumulus to date has been excavated and already is the largest excavation to take place in Albania. Although the settlement related to the tumulus has yet to be located, the history of the cemetery is known.

Within the tumulus, a central grave was found within a ring of stones hosting some further 40 graves dated to the late Bronze Age. There is also a second burial phase at the tumulus described by Albanian archaeologists as lasting four centuries.

This second phase consisted of graves being placed outside of the and over the stone ring. Finally, at the end of the 7th century BC, the cemetery was extended by a dense addition of rocks and graves suggesting a population growth.

In total 395 graves have been excavated from simple pits, to wooden and stone structures, along with some cremations. The skeletal material allowed for a total of 128 individuals to be used for this study (68 Males, 57 Females, and 3 Indeterminate). The skeletal material promises to shed more light on the population of the tumulus.

The sample from Vithkuq consisted of 52 whole individual femora, not articulated. These femora were sided, but not sexed. Twenty-six femora were from the right side of the body and twenty-six from the left side. Vithkuq is a late 18th century monastery. Translations of the history of the site are in the process of being translated by the Albanian Archaeological Institute director, Lorenc Benjko.

In order to find statistical significant results from the data collected at the two Albanian sites, measurements from a documented skeletal collection were needed. The comparative data were collected from the documented Hamann-Todd Osteological Collection housed at Cleveland's Museum of Natural History in Cleveland, Ohio. The Hamann-Todd Osteological Collection is named after Carl August Hamann and T. Wingate Todd. Today, the collection consists of 3,100 modern industrial human skeletons from the late 1800's and early 1900's. Each individual in the collection is accompanied by a wealth of information including records of age at death, ethnicity, sex, height, weight, and cause of death.

Of the Hamann-Todd collection, data from 200 White adult individuals were obtained, left and right femora from both 100 males and 100 females. Collectively,

the Hamann-Todd white sample is a group of mixed ancestry with some coming from Italy, France, and the Balkans, and the majority from “that region of Europe extending from the Rhine to Riga and from the northern seas through the hinterland as far as the Danube” (Todd 1928:38).

Measurement Protocol

The protocol for this study was developed at the Wichita State Biological Anthropology Laboratory using the WSU-BAL cadaver collection. The protocol comprised twenty-five traditional and non-traditional measurements (Table 1). All measurements were selected or designed to test the proximal femur for differences in shape, size, sex, and side.

All measurements were taken with standard equipment including both sliding and coordinate calipers, an osteometric board, and a fiberglass tape. Each measurement was recorded in millimeters and detailed on standard data collection forms (Appendix A). Upon completion, the data was transferred to an electronic format and screened for transcription and/or recording errors.

Twenty-five measurements were taken on each adult individual from the site of Kamenica and on the Hamann-Todd collection. Two of the twenty-five measurements were later omitted from the study due to a lack of precision and ability to collect them consistently on the femur. For the site of Vithkuq, only eight measurements (VHD, APG, MLG, APD, MLD, APS, MLS, FMC) were taken on each individual femur. Standard measurements were used along with others developed by this researcher and Dr. Moore-Jansen in the WSU-BAL lab. Traditional measurements included maximum bone lengths, diaphyseal

anteroposterior and mediolateral diameters, diaphyseal circumferences, breadth, and maximum and minimum diameters (Jantz and Moore-Jansen 1988; Moore-Jansen 1999). Diaphyseal diameters have been demonstrated to be statistically significant in distinguishing between groups (Wescott 2005).

In defining where the exact location anteroposterior and mediolateral diameters of the subtrochanteric region should be taken, the researcher discovered two variations for these in published works. One defined by Bass (1995), describes the anteroposterior and mediolateral subtrochanteric diameters, as taken just inferior to the lesser trochanter of the proximal femur, avoiding the gluteal tuberosity. Bass also states that in cases where this location cannot be determined, the measurement should be recorded 2-5mm below the lesser trochanter. Alternatively, other research defined the anteroposterior and mediolateral diameters to be taken just inferior to the lesser trochanter, not specifying to avoid the gluteal tuberosity (McHenry 1978, Gill and Rhine 1990, Miller 1995).

Table 1. Protocol Measurements



1. Maximum length (FML): The distance from the most superior point on the head of the femur to the most inferior point on the distal-medial condyle. Use an osteometric board (Moore-Jansen, Ousley, Jantz, 1994:68 and Martin and Saller 2002:231).

Table 1 (cont'd)



2. Bicondylar length (FBL): The distance from the most superior point on the head of the femur to a plane drawn along the inferior surfaces of the distal condyles. Use an osteometric board (Moore-Jansen, Ousley, Jantz, 1994:68).



3. Trochanteric length (FTL): Length taken from the most superior point on the greater trochanter to the most distal point on the distal-lateral condyle. Use an osteometric board (Martin and Saller, 1957 and Zobeck 1983:130).



4. Greater trochanter- subtrochanteric with gluteal tuberosity length (GSG): Measurement taken from the most superior point on the greater trochanter to the point of greatest lateral expansion of the femur below the lesser trochanter including the gluteal tuberosity. Use sliding calipers (Moore-Jansen and Brown).



5. Greater trochanter- subtrochanteric length (GSL): Measurement taken from the most superior point on the greater trochanter to the point of greatest lateral expansion of the femur below the lesser trochanter avoiding the gluteal tuberosity. Use sliding calipers (Moore-Jansen and Brown).

Table 1 (cont'd)



6. Greater trochanter- midshaft length (GML): Length taken from the most superior point on the greater trochanter to the midshaft of the femur. Use sliding calipers (Moore-Jansen and Brown).

Removed from results



7. Proximal breadth (FPB): Maximum width from the head of the femur to the greater trochanter perpendicular to the osteometric board. Use an osteometric board (Martin and Saller 200:232).



8. Proximal angled breadth (PAB):

Measurement taken posteriorly from the inferior-lateral point of the greater trochanter to the most medial point on the femoral head. Use sliding calipers (Moore-Jansen and Brown).



9. Neck vertical diameter (NVD):

Minimum diameter of the neck of the femur at the superior-inferior direction. Use sliding calipers (Martin and Saller, 2002:232).

Table 1 (cont'd)



10. Neck transverse diameter (NTD): Minimum diameter of the neck of the femur at the anterior-posterior direction. Use sliding calipers (Martin and Saller, 2002:232).



11. Vertical diameter of head (VHD): The maximum diameter of the femoral head taken in the vertical plane that passes through the axis of the neck. Use sliding calipers (Ingalls, 1924:212).



12. Horizontal diameter of head (HHD): The maximum diameter of the femoral head taken in the horizontal plane perpendicular to the vertical diameter of the head. Use sliding calipers (Ingalls, 1924:212).



13. Anterior-posterior subtrochanteric diameter with gluteal tuberosity (APG): The anterior-posterior diameter measured at the point of greatest lateral expansion of the femur below the lesser trochanter including the gluteal tuberosity. Use sliding calipers (Moore-Jansen and Brown).



14. Medial-lateral subtrochanteric diameter with gluteal tuberosity (MLG): The medial-lateral diameter measured at the point of greatest lateral expansion of the femur inferior to the lesser trochanter including the gluteal tuberosity. Use sliding calipers (Moore-Jansen and Brown).

Table 1 (cont'd)



15. Subtrochanteric circumference with gluteal tuberosity (SCG): The circumference measured on the shaft inferior to the lesser trochanter at the same level of the sagittal and transverse subtrochanteric diameters including the gluteal tuberosity. Use fiberglass tape.



16. Anterior-posterior subtrochanteric diameter (APD): The anterior-posterior diameter measured at the point of the greatest lateral expansion of the femur inferior to the lesser trochanter, avoiding the gluteal tuberosity. In cases where this cannot be determined, this measurement is recorded within 2-5 cm inferior to the lesser trochanter. Use sliding calipers (Moore-Jansen, Ousley, Jantz, 1994:69).



17. Medial-lateral subtrochanteric diameter (MLD): The transverse diameter measured at the point of greatest lateral expansion of the femur inferior to the lesser trochanter, avoiding the gluteal tuberosity. In cases where this cannot be determined, this measurement is recorded within 2-5 cm inferior to the lesser trochanter. Use sliding calipers (Moore-Jansen, Ousley, Jantz, 1994:69).



18. Subtrochanteric circumference (STC): The circumference measured on the shaft below the lesser trochanter at the same level of the sagittal and transverse subtrochanteric diameters, avoiding the gluteal tuberosity. Use fiberglass tape.

Table 1 (cont'd)



19. Anterior-posterior diameter at midshaft (APS):

The anterior-posterior diameter measured approximately at the midpoint of the diaphysis, at the highest elevation of the linea aspera. This measurement is perpendicular to the ventral surface. Use sliding calipers (Moore-Jansen, Ousley, Jantz, 1994:69).



20. Medial-lateral diameter at midshaft (MLS):

Measurement taken at right angles to the anterior-posterior diameter of the midshaft. The linea aspera should be midway between the two branches of the caliper. Use sliding calipers (Bass, 1995:224-225).



21. Circumference at midshaft (FMC):

The circumference measured at the midshaft at the same level of the sagittal and transverse diameters. Note: that if the linea aspera is strongly accentuated at the midshaft and not across a larger part of the diaphysis, this measurement should be recorded approximately 10 mm superior to the midshaft. Use fiberglass tape (Moore-Jansen, Ousley, Jantz, 1994:70).

22. Curvature of femoral shaft (CFS): Measurement taken on the posterior femoral shaft on the linea aspera. With the middle point set at midshaft, lateral points on the caliper should be moved to 8mm apart on each side. Record the depth. Use coordinate calipers (Moore-Jansen and Brown). **Removed from results**

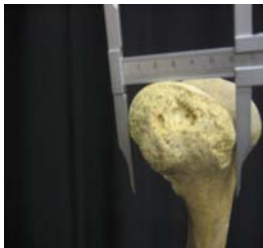
Table 1 (cont'd)



23. Epicondylar breadth (FEB): The maximum distance from the most lateral point on the lateral condyle to the most medial point on the medial condyle taken parallel to the infracondylar angle. Use an osteometric board (Moore-Jansen and Jantz 1989:79).



24. Femur anterior-posterior diameter of the lateral condyle (APL): Measurement taken of the projected distance between the most posterior point on the lateral condyle and lip of the patellar surface perpendicular to the axis of the shaft. Use sliding calipers (Montagu, 1960).



25. Femur anterior-posterior diameter of the medial condyle (APM): Measurement taken of the projected distance between the most posterior point on the medial condyle and lip of the patellar surface perpendicular to the axis of the shaft. Use sliding calipers (Montagu, 1960).

Statistical Procedures

Statistical procedures were used to discern morphological variation in the two Albanian samples and how they compared to the Hamann-Todd collection. Also, sexual dimorphism, asymmetry, and intra-observer error were examined in the skeletal samples using the statistical package SAS (SAS Statistical Institute Inc. 1989). Summary statistics were produced for Kamenica, Vithkuq, and Hamann-Todd

samples according to sex, side, and the platymeric index. A PROC t-test was performed to test for intraobserver error in the Kamenica sample. The t-test will look for differences between two measurements that were taken two-years apart that are significant at the 5% level.

CHAPTER 5

RESULTS

Summary Data

Summary statistics for the entire data set comprising the measurements recorded on the left and right femora from all three groups reveal observations of basic similarities and differences among and between the samples. All summary statistics were rounded to the nearest hundredth and reported in millimeters.

The summary data of the means for the Kamenica, Albania individuals grouped according to sex (Table 2) reveal a slight increase in the male anteroposterior and mediolateral diameters compared to the female means. Lengths, breadths, neck, and head diameters were also increased in the male sample. The greatest differences between the sexes reside in the following circumference measurements: femoral midshaft circumference (FMC), where males have a larger means of almost 9mm; the circumference at the lesser trochanter, including the gluteal tuberosity (SCG), with male means approximately 7mm larger; and the circumference at the subtrochanteric level avoiding the gluteal tuberosity (STC), almost 8mm above the female mean.

Means of the Kamenica, Albanian male sample separated into left and right femora (Table 3) show no significant side difference; although, the neck and head diameter means are slightly higher on the left side when compared to the right side. The lengths and breadths vary between sides, but this is attributed to the lack of a substantial sample size for those measurements.

Means of the Kamenica, Albanian female sample separated into left and right femora (Table 4) show that the majority of measurements that could be taken along

the shaft of the femur have no significant side difference. The only noticeable dimension difference is found in the neck vertical diameter means (NVD), which are larger on the left side by approximately 4mm.

The pooled means of the Vithkuq, Albania site (Table 5) were unidentified according to sex. The pooled means allow the researcher to compare them against the sexed Kamenica and the Hamann-Todd remains (Table 3, 4) in order to estimate possible sex. Side differences can be examined in the Vithkuq, Albanian sample (Table 6). The means between left and right sides are not significantly different, but the right side means are slightly larger.

Hamann-Todd collection means separated by sex (Table 7) reveal that the lengths, breadths, neck, and head diameters are significantly larger in the male sample. The anteroposterior and mediolateral diameters and circumferences are slightly larger in the male sample than in the female sample, where the most difference can be seen in the midshaft measurements (MLG, MLD, MLS). All variables are larger in the Hamann-Todd male collection than in the Kamenica male sample (Table 3), while the females in both samples are comparable.

The Hamann-Todd male collection was further separated into left and right side means (Table 8). No significant side difference was noted in the summary statistics. The Hamann-Todd female sample was also divided into left and right side means (Table 9). No significant side difference was found in the female means either.

Table 2. Kamenica Sex Means

VAR	MALES					FEMALES						
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
FML	5	463	408	440.2	23.49	551.7	1	438	438	438		
FBL	2	451	450	450.5	0.71	0.5	1	430	430	430		
FTL	3	441	415	432	14.73	217	0					
GSG	11	101	77	90	6.85	47	8	92	71	77.37	7.74	59.98
GSL	11	154	105	133.09	16.13	260.29	7	136	105	114	11.24	126.33
FBP	13	110	83	95.38	8.72	76.09	8	89	79	84.87	3.09	9.55
PAB	15	119	85	98.13	10.03	100.69	8	92	79	88	4.47	20
NVD	31	51	31	35.55	4.01	16.05	19	41	26	31.05	3.73	13.94
NTD	29	34	23	27.52	3.07	9.4	17	27	20	24.47	1.94	3.76
VHD	33	51	41	46.24	2.57	6.63	25	48	39	42.76	1.98	3.94
HHD	36	52	42	46.39	2.72	7.39	23	48	40	42.56	1.67	2.8
APG	99	32	22	26.17	1.96	3.84	65	29	19	23.66	2.02	4.07
MLG	98	40	27	33.48	2.65	7.03	64	36	26	31.05	2.45	6.01
SCG	97	110	83	94.74	5.34	28.55	64	96	78	87.17	4.16	17.32
APD	105	34	21	25.99	2.17	4.7	66	29	18	23.09	2.03	4.11
MLD	105	36	26	30.63	2.31	5.33	66	33	24	28.83	2.05	4.2
STC	104	102	80	90.07	4.78	22.86	66	91	73	82.53	4.04	16.34
APS	100	34	24	29.19	2.4	5.75	65	29	19	24.98	1.96	3.86
MLS	99	33	24	27.71	1.75	3.07	64	29	22	26.05	1.78	3.19
FMC	99	102	80	89.43	4.96	24.57	63	89	73	80.89	4.04	16.36
FEB	3	78	74	75.33	2.31	5.33	4	80	68	72	5.48	30
APL	5	62	55	59.8	2.95	8.7	2	61	57	59	2.83	8
APM	8	67	54	60.37	4	15.98	2	55	55	55	0	0

Table 3. Kamenica Male and Side Means

VAR	<u>LEFT SIDE</u>						<u>RIGHT SIDE</u>					
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
FML	2	454	423	438.5	21.92	480.5	3	463	408	441.33	29.3	858.33
FBL	1	450	450	450			1	451	451	451		
FTL	2	441	415	428	18.38	338	1	440	440	440		
GSG	6	101	84	91.33	5.54	30.67	5	96	77	88.4	8.56	73.3
GSL	6	154	106	135	16.17	261.6	5	147	105	130.8	17.65	311.7
FBP	9	109	83	95.11	7.94	63.11	4	110	83	96	11.63	135.33
PAB	10	117	85	97.2	9.39	88.18	5	119	88	100	12.14	147.5
NVD	16	51	31	37.06	4.64	21.53	15	40	31	33.93	2.43	5.92
NTD	14	34	24	28	3.51	12.31	15	31	23	27.07	2.63	6.92
VHD	18	51	41	46.55	2.87	8.26	15	50	43	45.87	2.2	4.84
HHD	15	52	42	46.67	3.09	9.52	21	52	42	46.19	2.48	6.16
APG	47	32	22	26.21	1.92	3.69	52	31	22	26.13	2.01	4.04
MLG	46	39	27	33.56	2.6	6.74	52	40	27	33.4	2.72	7.42
SCG	46	110	83	95.22	5.31	28.22	51	110	84	94.31	5.39	29.02
APD	51	31	21	26.16	2.01	4.05	54	34	22	25.83	2.31	5.35
MLD	51	36	26	30.9	2.31	5.33	54	35	26	30.37	2.3	5.29
STC	50	102	81	90.6	4.8	23.02	54	99	80	89.57	4.76	22.63
APS	52	34	24	29.08	2.39	5.72	48	34	25	29.31	2.42	5.88
MLS	51	32	24	27.82	1.74	3.03	48	33	24	27.58	1.77	3.14
FMC	51	101	81	89.74	5.03	25.35	48	102	80	89.1	4.9	24.05
FEB	1	74	74	74			2	78	74	76	2.83	8
APL	4	62	55	60	3.37	11.33	1	59	59	59		
APM	5	62	54	58.8	3.03	9.2	3	67	58	63	4.58	21

Table 4. Kamenica Female and Side Means

VAR	<u>LEFT SIDE</u>						<u>RIGHT SIDE</u>					
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
FML	1	438	438	438			0					
FBL	1	430	430	430			0					
FTL	0						0					
GSG	2	82	71	76	7.78	60.5	6	92	71	77.67	8.45	71.47
GSL	1	105	105	105			6	136	106	115.5	11.52	132.7
FBP	3	86	83	84.33	1.53	2.33	5	89	79	85.2	3.9	15.2
PAB	3	92	84	88.33	4.04	16.33	5	92	79	87.8	5.17	26.7
NVD	8	41	28	33.12	4.67	21.84	11	32	26	29.54	1.97	3.87
NTD	6	27	20	24.17	2.4	5.77	11	27	21	24.64	1.75	3.05
VHD	9	44	41	42.67	1.12	1.25	16	48	39	42.81	2.37	5.63
HHD	9	44	41	42.55	1.01	1.03	14	48	40	42.57	2.03	4.11
APG	28	26	19	23.57	1.83	3.36	37	29	19	23.73	2.17	4.7
MLG	27	35	26	31.11	2.53	6.41	37	36	26	31	2.43	5.89
SCG	27	96	78	87.55	4.36	19.02	37	94	80	86.89	4.05	16.38
APD	29	26	18	23.03	1.8	3.25	37	29	20	23.13	2.21	4.9
MLD	29	33	25	29.1	2.14	4.6	37	32	24	28.62	1.98	3.91
STC	29	91	73	83.24	4.4	19.4	37	88	74	81.97	3.7	13.69
APS	29	29	23	25.48	1.8	3.26	36	28	19	24.58	2.02	4.08
MLS	30	29	23	26.3	1.53	2.35	34	29	22	25.82	1.98	3.91
FMC	29	87	73	81.52	3.86	14.9	34	89	73	80.35	4.18	17.45
FEB	1	68	68	68			3	80	69	73.33	5.86	34.33
APL	0						2	61	57	59	2.83	8
APM	1	55	55	55			1	55	55	55		

Table 5. Vithkuq Pooled Means

VAR	n	MAX	MIN	MEAN	STD DEV	VARIANCE
VHD	52	52	39	45.48	3.6	12.96
APG	52	31	22	26.46	2.35	5.55
MLG	52	38	26	32.1	2.27	5.15
APD	52	30	22	25.02	1.92	3.7
MLD	52	32	25	29.6	1.72	2.95
APS	52	33	24	27.86	2.23	4.98
MLS	52	30	22	26.11	1.79	3.2
FMC	52	100	73	85.38	5.63	31.65

Table 6. Vithkuq Side Means

VAR	<u>LEFT SIDE</u>						<u>RIGHT SIDE</u>					
	N	MAX	MIN	MEAN	STD DEV	VARIANCE	N	MAX	MIN	MEAN	STD DEV	VARIANCE
VHD	26	52	39	44.88	3.71	13.79	26	52	40	46.08	3.45	11.91
APG	26	31	22	25.81	1.96	3.84	26	31	23	27.11	2.57	6.59
MLG	26	35	26	31.19	1.94	3.76	26	38	28	33	2.24	5.04
APD	26	28	22	24.69	1.78	3.18	26	30	22	25.35	2.04	4.15
MLD	26	32	25	29.19	1.7	2.88	26	32	26	30	1.67	2.8
APS	26	32	24	27.38	2.12	4.49	26	33	25	28.35	2.28	5.19
MLS	26	28	23	25.77	1.56	2.42	26	30	22	26.46	1.96	3.86
FMC	26	95	73	84.15	5.04	25.41	26	100	79	86.61	6	36

Table 7. Hamann-Todd Collection Means by Sex

VAR	MALE						FEMALE					
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
FML	201	530	391	450.08	21.46	460.55	199	481	340	416.94	23.1	533.87
FBL	201	529	387	447.29	21.42	458.99	199	475	339	412.78	23.1	533.49
FTL	201	503	375	432.93	20.37	415.16	200	456	332	400.87	21.7	470.86
GSG	201	106	75	89.6	5.5	30.24	200	97	67	80.33	5.63	31.75
GSL	201	144	103	122.99	7.59	57.64	200	133	95	111.95	7.63	58.2
FBP	201	110	78	94.48	5.52	30.52	198	102	70	83.04	5.8	33.61
PAB	201	115	85	99.54	5.31	28.18	199	106	76	88.84	5.45	29.67
NVD	201	43	27	35.43	2.63	6.92	199	38	25	30.54	2.23	4.97
NTD	201	34	22	27.85	2.09	4.36	199	32	20	24.52	2	3.99
VHD	201	96	41	48.69	4.15	17.22	199	48	38	42.65	2.07	4.28
HHD	200	54	41	47.82	2.28	5.21	198	48	37	42.23	2.05	4.22
APG	201	39	24	28.89	2.59	6.69	200	32	21	26.7	2.13	4.54
MLG	201	40	26	33.37	2.41	5.82	200	37	20	30.01	2.5	6.09
SCG	201	116	87	100.11	4.88	23.85	200	108	76	91.36	5.38	28.92
APD	201	33	23	28.17	2.09	4.37	200	30	20	25.73	1.86	3.46
MLD	201	37	24	31.28	2.34	5.49	200	35	23	27.6	2.38	5.65
STC	201	104	81	93.87	4.47	19.97	200	98	71	84.51	4.72	22.25
APS	201	34	24	28.8	1.93	3.73	200	30	21	26.08	1.83	3.37
MLS	201	34	23	29.2	1.94	3.76	200	31	21	25.7	2	4.01
FMC	201	102	78	90.86	4.36	19.06	200	94	70	81.48	4.39	19.27
FEB	201	91	72	83.07	3.34	11.15	198	82	65	74.39	3.2	10.22
APL	201	71	55	63.66	3.02	9.14	199	68	49	58.16	3.01	9.09
APM	201	71	54	63.49	3.15	9.95	200	69	50	57.95	3.09	9.57

Table 8. Hamann-Todd Collection Male and Side Means

VAR	<u>LEFT SIDE</u>						<u>RIGHT SIDE</u>					
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
FML	100	530	391	449.88	21.63	467.96	101	528	392	450.28	21.39	457.74
FBL	100	529	390	447.59	21.42	458.91	101	527	387	446.99	21.53	463.47
FTL	100	503	379	433.78	20.52	421.26	101	501	375	432.1	20.29	411.85
GSG	100	106	75	90.05	5.62	31.64	101	101	78	89.16	5.36	28.75
GSL	100	144	103	123.14	8	64.1	101	141	104	122.85	7.2	51.79
FBP	100	110	78	93.95	5.62	31.58	101	109	80	95	5.4	29.22
PAB	100	115	86	99.71	5.41	29.3	101	113	85	99.38	5.22	27.3
NVD	100	42	28	35.45	2.66	7.1	101	43	27	35.41	2.61	6.8
NTD	100	34	22	27.45	2.06	4.25	101	33	22	28.26	2.05	4.19
VHD	100	55	41	48.49	2.49	6.21	101	96	41	48.88	5.31	28.2
HHD	100	54	41	47.8	2.33	5.43	100	54	41	47.84	2.25	5.04
APG	100	39	24	28.93	2.77	7.66	101	36	24	28.84	2.41	5.79
MLG	100	40	28	33.29	2.41	5.8	101	40	26	33.45	2.43	5.89
SCG	100	116	87	99.86	5.08	25.82	101	112	87	100.37	4.69	22.01
APD	100	33	24	28.23	2.07	4.28	101	33	23	28.11	2.12	4.5
MLD	100	36	24	31.23	2.38	5.67	101	37	25	31.34	2.32	5.36
STC	100	104	82	93.98	4.55	20.71	101	104	81	93.77	4.41	19.42
APS	100	34	25	28.63	1.89	3.59	101	34	24	28.96	1.96	3.86
MLS	100	34	23	29.54	2.09	4.39	101	33	25	28.86	1.71	2.94
FMC	100	101	78	90.96	4.37	18.81	101	102	80	90.77	4.41	19.48
FEB	100	91	73	82.95	3.35	11.24	101	90	72	83.19	3.34	11.15
APL	100	71	55	63.83	2.97	8.81	101	70	55	63.49	3.08	9.51
APM	100	70	54	63.3	3.12	9.73	101	71	54	63.67	3.19	10.2

Table 9. Hamann-Todd Collection Female and Side Means

VAR	LEFT SIDE						RIGHT SIDE					
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
FML	99	481	347	417.01	23.09	533.27	100	475	340	416.87	23.23	539.85
FBL	99	475	347	413.38	23.11	533.97	100	470	339	412.18	23.19	537.66
FTL	100	456	337	401.83	21.76	473.33	100	454	332	399.91	21.71	471.27
GSG	100	97	67	81.16	5.84	34.11	100	92	69	79.5	5.32	28.31
GSL	100	133	95	112.48	7.84	61.52	100	130	95	111.42	7.41	54.89
FBP	99	98	70	82.63	5.7	32.46	99	102	70	83.46	5.89	34.74
PAB	99	105	77	89.08	5.46	29.83	100	106	76	88.61	5.45	29.69
NVD	99	36	26	30.53	2.22	4.94	100	38	25	30.55	2.24	5.04
NTD	99	32	20	24.35	2.05	4.19	100	29	20	24.69	1.94	3.77
VHD	99	48	38	42.66	2.07	4.27	100	48	38	42.64	2.08	4.33
HHD	99	48	37	42.13	2.04	4.18	99	47	38	42.32	2.07	4.28
APG	100	32	21	26.76	2.21	4.9	100	31	22	26.64	2.06	4.23
MLG	100	36	20	29.86	2.55	6.5	100	37	25	30.17	2.39	5.7
SCG	100	105	76	91.14	5.28	27.9	100	108	77	91.58	5.49	30.14
APD	100	30	20	25.87	2.01	4.03	100	30	21	25.59	1.7	2.9
MLD	100	34	23	27.59	2.28	5.19	100	35	23	27.62	2.48	6.16
STC	100	97	71	84.64	4.61	21.24	100	98	72	84.38	4.84	23.45
APS	100	30	21	26.04	1.92	3.67	100	30	22	26.12	1.76	3.1
MLS	100	31	21	25.92	2.01	4.05	100	31	21	25.49	1.98	3.91
FMC	100	94	70	81.64	4.45	19.85	100	90	71	81.33	4.34	18.83
FEB	99	82	65	74.34	3.29	10.8	99	82	65	74.44	3.12	9.74
APL	100	68	50	58.36	3.02	9.12	99	68	49	57.96	3.01	9.08
APM	100	69	50	57.83	3.17	10.04	100	69	51	58.08	3.03	9.16

Platymeric Index Means

Platymeric index means were also statistically measured in the three skeletal samples (Table 10). The index means were taken at three places on the femur. The first index means (APGIND) consisted of the anteroposterior and mediolateral diameters taken at the subtrochanteric level just inferior to the lesser trochanter including the gluteal tuberosity. The second index means (APDIND) utilized the a-p and m-l diameters taken at the subtrochanteric level avoiding the gluteal tuberosity. The final index means (APMIND) used the a-p and m-l diameters taken at the midshaft. The APMIND means were taken to see how the overall size and shape of the diaphysis correlates to the proximal index measurements.

The platymeric index means for each sample (Table 10) display that the Kamenica femoral remains are the most platymeric (<85mm) for the APG and APD indices. The Vithkuq femoral remains are also platymeric (<85mm) for these two indices, but to a lesser degree than the Kamenica remains. The Hamann-Todd sample is clearly eurymeric (>85mm).

Table 10. Platymeric Index Means

VAR	n	MAX	MIN	MEAN	STD DEV	VARIANCE
KAMENICA						
APGIND	165	111.54	60.61	77.49	8.44	71.33
APDIND	173	130.77	63.89	83.44	10.06	101.16
APMIND	163	128	76	102.05	10.37	107.52
VITHKUQ						
APGIND	52	110.71	71.43	82.67	7.77	60.33
APDIND	52	100	68.75	84.75	7.39	54.62
APMIND	52	131.82	89.28	106.97	8.78	77.12
HAMANN-TODD						
APGIND	401	135	67.57	88.16	9.26	85.72
APDIND	401	130.43	65.71	92.21	10.1	101.94
APMIND	401	132	77.78	100.44	8.92	79.5

The platymeric index means can be further examined in the Kamenica and Hamann-Todd samples when they are divided by sex means (Table 11). The results of the platymeric index means disclose that females of Kamenica have the most platymeria in all indices (APGIND, APDIND, APMIND) for all three samples. The table also shows how as the index measurements move down the shaft of the femur in the Kamenica sample, the means clearly separate the sexes with the male sample always larger, less platymeric than the female sample. On the other hand, as the index measurements progress down the shaft of the femur in the Hamann-Todd collection, it is the female means that are larger, thus the males are more platymeric. Overall, males and females in the Kamenica sample are platymeric and both sexes of the Hamann-Todd sample are eurymeric.

Table 11. Platymeric Index Means by Sex

VAR	n	MAX	MIN	MEAN	STD DEV	VARIANCE	N	MAX	MIN	MEAN	STD DEV	VARIANCE
	<u>MALE</u>						<u>FEMALE</u>					
	KAMENICA											
APGIND	98	100	64.7	78.38	7.43	55.16	64	76.61	60.61	76.61	9.6	92.23
APDIND	105	130.77	63.89	85.33	9.82	96.54	66	80.56	65.62	80.56	9.92	98.35
APMIND	99	128	84.37	105.7	9.55	91.14	63	96.25	76	96.25	8.97	80.42
	HAMANN-TODD											
APGIND	201	130.77	67.57	86.97	9.72	94.54	200	135	72.22	89.37	8.62	74.38
APDIND	201	120.83	65.71	90.61	10.13	102.65	200	130.43	71.43	93.81	9.83	96.59
APMIND	201	132	79.41	98.97	8.36	69.9	200	126.09	77.77	101.93	9.23	85.14

Additionally, platymeric index means are described by the male sample in order to see sex and side differences for the Kamenica and Hamann-Todd collections (Table 12). For the Kamenica males there is no significance in variation between left and right sides, but there is slightly more platymeria shown in the left side means. The same results are seen for the males in the Hamann-Todd collection, where there is no significant difference in the side and there is slightly more platymeria on the left side.

Table 12. Platmeric Index Means by Male and Side

VAR	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
	<u>LEFT</u>						<u>RIGHT</u>					
	KAMENICA MALE											
APGIND	46	78.08	64.7	78.08	7.05	49.71	52	100	64.7	78.64	7.8	60.9
APDIND	51	111.54	63.89	85.02	8.22	67.51	54	130.77	70.97	85.62	11.21	125.58
APMIND	51	128	84.37	104.87	9.71	94.37	48	126.92	90	106.53	9.39	88.2
	HAMANN-TODD MALE											
APGIND	100	120.69	69.44	87.26	9.54	91.01	101	130.77	67.57	86.67	9.94	98.8
APDIND	100	120.83	70.59	90.99	10.33	106.78	101	116	65.71	90.24	9.96	99.3
APMIND	100	125.92	79.41	97.34	8.78	77.11	101	132	80.64	100.57	7.63	58.22

Finally, platymeric index means are categorized into female and side groups for both Kamenica and Vithkuq (Table 13). The Kamenica females are shown to be slightly more platymeric on the left side for the APG and APD indices, but the APMIND is more platymeric on the right side. The Hamann-Todd females display the opposite. The APG and APD indices are slightly more platymeric in the right sample, whereas the APMIND is more platymeric in the left side sample.

Table 13. Platymeric Index Means by Female and Side

VAR	n	MAX	MIN	MEAN	STD DEV	VARIANCE	N	MAX	MIN	MEAN	STD DEV	VARIANCE	
		<u>LEFT</u>						<u>RIGHT</u>					
		KAMENICA FEMALE											
APGIND	27	100	65.62	75.91	8.28	68.59	37	111.54	60.61	77.12	10.55	111.23	
APDIND	29	100	66.67	79.54	8.44	71.23	37	112.5	65.62	81.36	10.98	120.67	
APMIND	29	116	82.14	97.27	8.51	72.4	34	118.18	76	95.38	9.38	87.96	
		HAMANN-TODD FEMALE											
APGIND	100	135	72.41	90.13	9.72	94.49	100	119.23	72.22	88.6	7.34	53.84	
APDIND	100	130.43	71.43	94.31	9.93	98.62	100	116.67	72.41	93.31	9.75	95.04	
APMIND	100	121.74	77.78	100.92	9.36	87.65	100	126.09	83.87	102.93	9.02	81.44	

Furthermore, platymeric index means for Vithkuq were examined for left and right side differences (Table 14). The results from this observation show no significant difference between sides. The results may represent that the single, unarticulated femora from the left and right side from Vithkuq could be matched to individuals and thus show no significance in side differences.

Table 14. Vithkuq Platymeric Index Means by Side

VAR	LEFT						RIGHT					
	n	MAX	MIN	MEAN	STD DEV	VARIANCE	n	MAX	MIN	MEAN	STD DEV	VARIANCE
APGIND	26	110.71	73.53	83.01	7.97	63.57	26	100	71.43	82.33	7.7	59.26
APDIND	26	100	68.75	84.84	7.52	56.54	26	100	74.19	84.66	7.41	54.88
APMIND	26	123.08	89.28	106.44	7.94	63.04	26	131.82	89.28	107.5	9.68	93.69

Platymeric indices from the three samples in this study can then be compared to published platymeric index reports for other groups (Table 15). Wescott (2005) published reports from his study on five populations. The Hamann-Todd fit expectedly into Wescott's sample of American Whites and Blacks. The Kamenica and Vithkuq sites are not closely comparable to any of the groups, but relate more to the Native American sample.

Table 15. Platymeric Index by Groups

GROUP	SEX	n	MEAN	STD DEV
Native Americans*	M	887	79.2	10
	F	808	76.9	8.8
Polynesians*	M	71	71.4	5.5
	F	108	70.1	5
Hispanic*	M	34	89.2	13.4
	F	7	86.7	5.7
American Black*	M	183	90.6	8.5
	F	137	92.7	10.8
American White*	M	403	90.3	8.9
	F	265	89.5	9.4
Kamenica	M	105	85.3	9.8
	F	66	80.6	9.9
Vithkuq	Unknown	52	84.7	7.4
Hamann-Todd	M	201	90.6	10.1
	F	200	93.8	9.8

* (Wescott 2005)

Intraobserver Error

PI measurements (APG and MLG) collected by the researcher in 2003 and again in 2005 from the Kamenica collection (Table 16, 17) were tested for intraobserver error. The same individual femora were measured for both variables after a two-year period in order to validate the accuracy of the measurements and thus validate the use of the PI index in defining population differences. The results from the t-test performed show that there was no intraobserver error (no significance, because $p > t$ equals above .05 in all instances).

Table 16. Intraobserver Error for Kamenica (APG)

OBS	VAR	<u>LEFT*</u>			<u>RIGHT**</u>		
		n	MEAN	STD DEV	n	MEAN	STD DEV
2003	APG	44	24.7	1.93	52	24.1	2.39
2005	APG	44	25.1	1.98	52	24.9	2.23
Diff (03-05)			-0.43	1.95		-0.86	2.31

* $t = -1.04$; $p > t = .303$

** $t = -1.91$; $p > t = .059$

Table 17. Intraobserver Error for Kamenica (MLG)

OBS	VAR	<u>LEFT*</u>			<u>RIGHT**</u>		
		n	MEAN	STD DEV	n	MEAN	STD DEV
2003	MLG	44	32.14	2.72	52	31.69	2.35
2005	MLG	44	32.34	2.99	52	31.98	2.85
Diff (03-05)			-0.2	2.86		-0.29	2.61

* $t = -.34$; $p > t = .738$

** $t = -.56$; $p > t = .575$

CHAPTER 6

DISCUSSION

Introduction

The preceding chapters have covered the femur and its importance to morphological research in anthropology. Differences among the shape of the femur can be either genetic, environmental, or both. The use of platymetric indices have been successfully used by researchers such as Gill and colleagues (1990, 2001) to estimate ancestry and distinguish between Native Americans and American Whites and American Blacks, suggesting differences are genetic. But, there is also research that demonstrates interdependence between the structure of the femur and biomechanical stress (Wescott 2005). The results of this study, which will be discussed throughout this chapter, suggest both biomechanics and genetics likely play a role. By analyzing the proximal femur with a biomechanical approach and its influence on shape, this study adds depth to recent discussions in anthropological research on morphology.

The preceding chapters have provided the foundation for investigating the proximal femur and whether differences within and among groups can be observed. The variation of femur shape and size was first described by its anatomy and physiology. To successfully conduct a study using a biomechanical approach the basic features of the femur and the muscles acting upon its surface needed to be understood. The prominent muscle

attachment sites such as the lesser trochanter, gluteal tuberosity, and linea aspera can change with increased muscle activity and ultimately affect the overall shape of the proximal femur.

Upon knowing the anatomy of the modern human femur, a comparison with non-human primates and hominoid specimens in regards to shape and function could be possible. By comparing modern human femur structure to non-human primates and in an evolutionary context, the shape of the proximal femur and its place in a broader context is known.

Past research on the morphology of the femur was also covered in the previous sections. Femoral studies of sexual dimorphism, biomechanics, asymmetry, and intraobserver error were presented as they relate to the present study. The preceding studies were essential in preparing a protocol, in providing results to compare the present study against, and relaying insight into how this study contributes to morphological understanding of populations.

How the femur forms and what factors affect its shape seem like simple questions with straightforward answers. The tools, measurement techniques, and research methods in describing the proximal femur shape also appear uncomplicated. When realizing the various influences that can affect the shape of the femur, the process of describing shape differences among and between populations is not as definite as it may appear. The biological anthropologist is equipped with the knowledge of variation within human bone. This resource is what allows distinctions such as, sexual dimorphism and side differences, to be discerned within and between different skeletal samples.

If the same effects or influences on the femur are consistent among individuals in a group, quantitative distinctions can be made. The platymeric index is a useful tool for biological anthropologists in distinguishing individuals within a population and

characterizing certain groups from others. In order to understand the overall morphology of the proximal femur in these three populations, the proceeding discussion of the findings should be considered with an anthropological perspective.

Population Differences

Based on the quantitative analyses, it is concluded that variations in the proximal femoral shape exist among and between the three skeletal samples. Each skeletal collection varies from one another to a certain degree, either by overall size, shape, or by the degree of platymeria. In order to fully examine how such variables influence the shape of a skeletal population, the specifics of such elements must be known to the researcher. The Hamann-Todd documented collection allows for variables to be better estimated, because the remains have a known age at death, sex, group affiliation, and height, and cause of death. Therefore, in order to compare how the two Albanian samples differ from one another they must first be compared to the Hamann-Todd collection.

Hamann-Todd

Based on length measurements, the males in the Hamann-Todd sample have significantly longer femora (Table 6). The average length of the male femur is 450.08mm, while the female mean is 416.94mm. This basic size difference between the males and females is also noticed in the head diameters, where the maximum vertical and horizontal head diameters average around 48mm for males and females average approximately 42mm. In fact, all of the twenty-three measurements taken show the males to be much larger and more robust throughout the entire femur.

When the focus is narrowed to those measurements just below the lesser trochanter to the midshaft (APG-FMC), a better picture of the femoral diaphysis shape is revealed. The a-p diameters throughout the shaft in males and females are quite consistent, most likely due to the structure of the line aspera. The linea aspera is usually stable in size, because it provides an attachment site for those muscles needed for upright posture. For males, the most proximal a-p measurement mean is 28.89mm, avoiding the gluteal tuberosity it is 28.17mm, and at the midshaft it is 28.8mm. The female means respectively are 26.7mm, 25.73mm, and 26.08mm.

The mediolateral diameters along femoral shaft in males and females are not as consistent, showing some slight differences. Such that the diameters in the male sample begin proximally with a 33.37mm measure, to 31.28mm, and then at the midshaft to 29.2mm. The same sequence can be seen in the females where the most proximal a-p mean result is 30.01mm, then 27.6mm, and onto 25.7mm. The larger mediolateral diameters towards the proximal end are most likely the result of the gluteal tuberosity that is found laterally to the lesser trochanter. The effect the gluteal tuberosity can have on the mediolateral diameter is one reason why most researchers use the subtrochanteric diameters that avoid the gluteal tuberosity in platymetric studies.

Still focusing on the diameter measurements along the shaft of the femur, platymetric indices are established (Table 10). The platymetric index means show the Hamann-Todd sample to be clearly eurymeric for both sexes. For all three index means the Hamann-Todd male and female subtrochanteric region is over 85mm (Table 11). The rounded shape of the proximal femur was expected; since other researchers have also found this in samples of American White males and females (Table 15).

The pooled platymeric index means further demonstrate how diameter measurements grow larger as they get closer to the femoral midshaft. The most proximal subtrochanteric measurements taken with the gluteal tuberosity give a PI mean of 88.16mm. When the same measurements are taken without the gluteal tuberosity the PI mean result is 92.21mm, while at the midshaft PI means are 100.44mm. A noticeable observation is that the Hamann-Todd PI pooled means at the midshaft are the smallest of the three samples. The smaller APMIND provides a piece of the picture on how round or eurymeric the Hamann-Todd femora remains are shaped. When the APG, APD, and APM indices are compared, they are relatively grouped together suggesting the shape to be rather consistent with little mediolateral flattening.

When the platymeric indices are grouped according to sex the males are found to be the most platymeric (Table 10). Males have an APGIND of 86.97mm, an APDIND of 90.61mm, and an APMIND of 98.97mm. Whereas, the female means, in the same order, are 89.37mm, 93.81mm, and 101.93mm. It is suggested that the more platymeric males in the Hamann-Todd sample have the most mechanical stress being placed on the femur. The degree of sexual dimorphism found in the platymeric results will be discussed shortly.

Kamenica

The basic size and shape of the femur in the Kamenica sample can be described using the summary statistics (Table2). Just like the Hamann-Todd sample, the male means for all measurements are larger than the female means. The lack of whole femora in this archaeological sample makes it difficult for lengths to be compared, but the head diameters show basic sex difference. Males have an average femoral head diameter of 46mm, while females average 42mm. The difference between the sexes is only four millimeters compared

to the six millimeters found between the males and females in Hamann-Todd. The females in both samples average 42mm, whereas the males in the Hamann-Todd have a larger head diameter mean by two millimeters. The difference in head diameters can suggest that the Hamann-Todd males are more robust than the Kamenica males.

When attention is brought to the measurements concerning the shaft of the femur, the anteroposterior measurements are arranged similar to the Hamann-Todd. The anteroposterior measurements for males beginning just inferior to the lesser trochanter average 26.17mm, to 25.99mm, to 29.19mm. There is a slight increase towards the midshaft along the shaft of the Kamenica male femora. The females are more consistent in a-p measurements with 23.66mm, to 23.09mm, and on to the midshaft at 24.98mm.

The mediolateral diameter measurements in the Kamenica sample get smaller as the measures get closer to the midshaft, just like the Hamann-Todd. The mediolateral means of Kamenica males are 33.48mm, to 30.63mm, to 27.71mm. Female means in the same order start at 31.05, to 28.83, then on to 26.05mm.

The Kamenica males and females display the most platymeria when compared to the other two sites (Table 10). The femora from the females in Kamenica express even more platymeria yet (Table 11). The female APGIND means are 76.61mm, the APDIND means are 80.56mm, and APMIND means are 96.25mm. In comparison, the male APGIND means are 78.38mm, the APDIND means are 85.33mm, and the APMIND means are 105.67mm. Both males and females have a very large APMIND means when compared to the subtrochanteric platymeric index means. This differs from the not so divergent APMIND means found in Hamann-Todd. The dramatic increase towards the femoral midshaft reveal that the subtrochanteric region in the Kamenica sample is greatly mediolaterally flattened.

The shape of the proximal femur in the Kamenica sample matches the assumptions put forth by Ruff (2000), such that pre-industrial groups are more physically active and this increase in activity can be seen in the skeleton. The heavy pre-industrial agricultural work and the high-elevated terrain characterize the Kamenica site and the group of people who once inhabited it.

Vithkuq

The Vithkuq remains are different from the other samples, because they were sided but not sexed. It is hypothesized that the majority of the Vithkuq remains are male, based on the fact that the femora were found in the basement of a monastery. The aim of the researcher was to use the means provided for the Hamann-Todd collection and the Kamenica sample to make estimates of the sex of this group. Sex estimation will be based on how the range of shape and size in Vithkuq compares to the documented collection one from the same geographical region.

The results from the pooled Vithkuq means (Table 5) first reveal the average head diameter to be 45.48mm. The head diameter is significant in determining sex, as seen in the other two samples. The mean head diameter of 45.48 mm lies in between the Hamann-Todd collection means for, which are around 48mm and the Hamann-Todd female means of 42mm. The head diameter measurement of the Vithkuq sample closely compares to the Kamenica males who average 46mm, whereas the Kamenica female means average 42mm. Based on this first comparison, the average Vithkuq maximum head diameter is much larger than both female means and strongly compares to the Kamenica male sample.

Another good sex indicator in the skeleton is the femoral midshaft circumference. Males are known to be larger than females in this region, a fact that can be seen in the

Hamann-Todd and Kamenica remains (Table 2,6). The midshaft circumference for the Vithkuq remains average 85.38mm. This compares to the other populations as such: Hamann-Todd (90.86mm), Hamann-Todd females (81.48mm), Kamenica males (89.43mm), and the Kamenica females (80.89mm). The Vithkuq midshaft circumference means fall in between the sex ranges for both groups. The average of 85.38mm is larger than both female means, but no strong correlation between all samples can be made.

Additionally, the anteroposterior diameter measurements from the Vithkuq pooled sample are more closely resemble the Kamenica male a-p means. The a-p means for Vithkuq starting just below the lesser trochanter is 26.46mm, to 25.02mm, an ending at the midshaft with 27.86mm (Table 5). The Kamenica males a-p means respectively are 26.17mm, 25.99mm, and 29.19mm (Table 2). The remaining variables of the Vithkuq pooled sample lie in between the Kamenica male and Kamenica female samples. The exploration of which sex the Vithkuq remains are most likely of will be discussed further using the platymetric indices.

The Vithkuq sample is defined as platymetric, both APG and APD index means are less than 85mm. The extent of platymeria is expressed to lesser degree than in the Kamenica sample (77.49, 83.44), but the quantitative results reveal the shape is more mediolaterally broader than the Hamann-Todd.

Sexual Dimorphism

The results show sex differences within and among the two populations of Kamenica and Hamann-Todd. Within each of these two groups, females have smaller overall femoral measurements. When examining the sex differences within the Hamann-Todd population using the platymetric index, males are the most platymetric and thus exhibit

a slightly flatter subtrochanteric region. This observation goes against Wescott (2005) and Ruff (1987) argument that females will display more platymeria than males due to the wider pelvic breadth. Also, that the wider pelvic distance of females would result in greater mediolateral bending of the subtrochanteric region causing greater platymeria. If this anatomical reasoning holds true, the Hamann-Todd females should be the most platymeric, but they are not.

Females display more platymeria than males in the Kamenica populations. This observation would give credit to Wescott and Ruff's statement, but what if the platymeria is perhaps due to the women in Kamenica playing a significant role in agricultural production. The increased bending motion involved in pre-industrial agricultural work can affect the subtrochanteric region. As Morrison (1968,1969) states that activity-related mechanical loads result in the modeling of the femur shaft to be one that is more anteroposterior elongated and mediolaterally wider. The constant contraction of the hamstrings and quadriceps muscles in agricultural work in Kamenica could cause proximal femoral bending.

If this logic is applied to the Hamann-Todd sample where men are displaying more platymeria than the females in that population, then the argument can be put forth that the men in this sample during the late 1800's and early 1900's were the ones most involved in manual labor. It is known that the Hamann-Todd sample comes from the lower classes of the Cleveland, OH industrial area. Increased stress on the proximal femur during heavy labor could create the same mediolateral widening.

The results from this study show there is potential sexual dimorphism within the two samples and also between them. The differences within the two groups, such as the females being the most platymeric than the males in Kamenica, while in the Hamann-Todd sample males are the most platymeric, suggests sexual dimorphism. The differences between the

sexes within the groups can further indicate the division of labor in the populations. Using a biomechanical approach to the above results, platymeria can result because of the femoral plastic response to increased mechanical loads. Females in the Kamenica sample and White males in the Hamann-Todd could have endured more mechanical stress on the femur than their counterparts.

Asymmetry

All three samples were examined according to side differences. The quantitative results within each population show no significant difference between the left and right sides, thus no asymmetry was found. The systematic asymmetry favoring the left side in the lower limb reported by Shultz (1937), Latimer and Lowrance (1965), and Ruff and Jones (1981), was not observed in this study. There were some slight favoring of the left side in the three samples, but the side difference was not significant. Also, the observation by Ruff (2000) that more physically active pre-industrial populations have greater asymmetry was not found. Ruff (1987) states that reduced asymmetry in industrial groups may reflect a reduction in activity level or homogeneity of activity patterns. This reasoning could reflect why the modern, industrial Hamann-Todd sample displays no asymmetry.

An estimate on why there is no asymmetry in the Kamenica and Vithkuq remains could be due to the physical terrain. The Albanian landscapes for both site locations are on high terrain, where it is very rugged and mountainous. The lack of asymmetry may result from increased muscle activity being placed on both the left and right sides equally. More research needs to be done on the effects of increased or decreased activity levels and the physical terrain on asymmetry patterns.

PI Measurements

As a result of two definitions existing in published literature differing on where exact location subtrochanteric diameters should be taken, confusion in platymeric index results can occur. To control for the varied definition of the subtrochanteric region, anteroposterior and mediolateral diameters were taken just inferior to the lesser trochanter including the gluteal tuberosity (APG, MLG) and the same diameters were also taken inferior to the lesser trochanter avoiding the gluteal tuberosity (APD, MLD).

Platymeric indices by collection (Table 9) and by definitions demonstrate how the shape of the proximal femur can be used successfully and inadequately to distinguish group variation. When the APG index is utilized with those diameter measurements including the gluteal tuberosity, the three populations are successfully categorized. The Kamenica APGIND means of 77.49mm, the Vithkuq means of 82.69mm, and the Kamenica means of 88.16mm clearly separate and distinguish the populations.

On the other hand, if the populations were measured according to a variation of APG index and APD index definitions, the results are not as successful. One example being if the Kamenica remains were measured with the APD index measurements (83.44mm) and the Vithkuq remains were measured with APD index measurements (82.67mm), the results are not as clearly defined when using the APG index measurements consistently. Inconsistency on where index measurements are taken can obscure population differences. Additionally, researchers must consistently use one definition in order to comparing population platymeric index means to other published platymeric means. A standard, clearly defined definition is essential for the biological anthropology community to use the platymeric index as a valid tool in estimating differences within and among groups.

Intraobserver Error

A t-test was performed on the APG and MLG dimensions taken at Kamenica over a two-year span. The test was done to check the accuracy of the researcher in taking these measurements. With the high interobserver errors reported by Wescott (2005) and Adams and Byrd (2002), the researcher wanted to make sure the results obtained from the three samples reflected the shape differences correctly. The results of the t-test showed no significance ($p > .05$) for both variables. Therefore, the differences in shape among and between the populations were accurately described by the quantitative results.

Summary

The morphology of the proximal femur in these samples can be quantitatively and accurately described by using a variety of measurements. Quantitative results allowed the researcher to group the Kamenica and Vithkuq Albania samples into the platymeric population category, while the Hamann-Todd population was categorized as eurymeric. Sexual dimorphism was also displayed in the Kamenica and Hamann-Todd quantitative results, perhaps reflecting divisions of labor within the two groups. Side differences were not significantly revealed in any of the three skeletal samples. The platymeric index proved to be useful in distinguishing population differences. It was found that varied definitions on where to take platymeric measurements at the subtrochanteric level can obscure population differences. Finally, it was shown that testing the accuracy of the researcher's measurements through intraobserver error adds strength to the study. Overall, by examining the proximal femur morphology in three distinct samples a better understanding of population variation was obtained and the results contribute to the ongoing biomechanical investigations in anthropology.

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APPENDICES

APPENDIX A

RECORDING FORM

Morphological Variation of the Human Femur

JB# _____

Site Name _____

Sex: _____

Age: _____

Date: _____

Burial # _____

Group: _____

Lengths:		Left	Right
1	Maximum length (FML):		
2	Trochanteric length (FTL):		
3	Bicondylar length (FBL):		
Proximal breadths:			
4	Proximal breadth (FPB):		
5	Proximal angled breadth (PAB):		
Measurements of femoral neck:			
6	Neck vertical diameter (NVD):		
7	Neck transverse diameter (NTD):		
8	Neck length (FNL):		
Measurements of femoral head:			
9	Vertical diameter of head (VHD):		
10	Horizontal diameter of head (HHD):		
Subtrochanteric diameters with the gluteal tuberosity:			
11	Anterior-posterior subtrochanteric diameter with gluteal tuberosity (APG):		
12	Medial-lateral subtrochanteric diameter with gluteal tuberosity (MLG):		
13	Subtrochanteric circumference w/ gluteal tuberosity (SCG):		
Subtrochanteric diameters without the gluteal tuberosity:			
14	Anterior-posterior subtrochanteric diameter (APD):		
15	Medial-lateral subtrochanteric diameter (MLD):		
16	Subtrochanteric circumference (STC):		
Diameters at midshaft:			
17	Anterior-posterior diameter at midshaft (APS):		
18	Medial-lateral diameter at midshaft (MLS):		
19	Circumference at midshaft (FMC):		
20	Curvature of femoral shaft (CFS): (coordinate calipers)		
Distal femoral measurements:			
21	Epicondylar breadth (FEB):		
22	Femur a-p diameter of lateral condyle (APL):		
23	Femur a-p diameter of medial condyle (APM):		

