8-2013

Two of a Kind: Implications of Bilateral Directional Asymmetry on Pair Matching of Human Limb Bones.

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To the Graduate Council:

I am submitting herewith a thesis written by Lauren Ashley Garroway entitled "Two of a Kind: Implications of Bilateral Directional Asymmetry on Pair Matching of Human Limb Bones.." I have examined the final electronic 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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Two of a Kind: Implications of Bilateral Directional Asymmetry on Pair Matching of Human Limb Bones.

A Thesis Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Lauren Ashley Garroway
August 2013

Acknowledgements

In keeping with the vein (medullary cavity?) of bilateral symmetry, I present my acknowledgements in an ABAB rhyme scheme. On second thought, I think "LRLR" might be a bit more appropriate, considering all of the directional asymmetry calculations I did using left and right side measurements.

For days and weeks and months I toiled, on all these many pages,
While I read and wrote, and did lots and lots of math.
And as the time is nearing done I think on all the sages
Who helped to guide me on this path.

To my committee members, Amy, Lee, and Ben
For all you've done, on your own and as a whole;
With data, stats, and answers for each question -
I am indebted to you for your role.

Mom, you and I both know there's not enough that I can say,
About the support and laughs that come with every call,
And even though I'm grown, and much too far away
You've still got my back, just like when I was small.

Chris, it's not hard to say what it is I see in you,
And I'm reminded night and day,
When your drive in everything you do
Helps push me further on my way.

Alice, for taking time you didn't have to give me
To teach me things that made this project flow,
And my whole, new Rossbach family,
You've all helped me learn and grow.

So this is with gratitude, and humble thanks
That I've avoided so many could-be disasters.
Because of you, I've reached the ranks
Of all those who have their Master's.

Abstract

The task of sorting and analyzing commingled remains can be daunting, depending on the degree of fragmentation, distribution, and contents of the assemblage. The Most Likely Number of Individuals (MLNI) calculation for quantifying the contents of human skeletal assemblages is dependent upon the ability to properly match bilateral elements into pairs. Anthropologists employ numerous methods to reassociate commingled remains into discrete individuals, but the guiding principle used to match sided elements is "general symmetry" (Adams and Konigsberg, 2008; Byrd, 2008). However, different skeletal elements and regions within those elements are variably responsive to a combination of environmental and genetic factors. The degree to which certain skeletal regions are susceptible to these factors corresponds to the amount of asymmetry that is likely to be seen within them. For instance, diaphyseal shaft dimensions, which are strongly influenced by mechanical loading, exhibit more asymmetry than the more genetically-constrained regions, articular surfaces and lengths (Auerbach and Ruff, 2006). Skeletal asymmetry has been widely studied in prehistoric and preindustrial populations, but remains minimally explored within modern populations.

This study uses bilateral measurements from a modern sample of adult white males to test which long bone dimensions display the greatest directional asymmetry. Dimensions and skeletal regions that are more resistant to environmental influences, and therefore asymmetry, should be given preference when attempting to match elements. Results support earlier literature documenting the marked directional asymmetry within diaphyseal shaft dimensions, as well as limited plasticity within articular and peri-articular surface and length dimensions.

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Introduction

When confronted with the commingled remains of multiple individuals – victims of genocide buried in the same grave, or a family burned in a house fire, or homicide victims combined and damaged as the result of a secondary burial – the task falls to forensic anthropologists to estimate the number of individuals represented in the assemblage. Literature describing protocol for differentiating commingled individuals is scarce and traditionally limited to faunal and paleodemographic studies; modern forensic applications have only recently been explored (Adams and Konigsberg, 2008). Forensic anthropologists may rely on a suite of tools to sort commingled remains: age estimation of "ageable" elements; articulation; visual matching of analogs; seriation or osteometric sorting; overall morphology and individualizing characteristics; taphonomy; and DNA (Byrd, 2008) . Osteometric sorting employs regression formulae to statistically evaluate the likelihood of association between elements, such as the tibia and femur. Both osteometric sorting and DNA comparison are objective and have known error rates, making them useful tools in courts that are increasingly insistent on statistically-sound methodologies (Byrd and Adams, 2009).

Estimating the number of individuals in a commingled assemblage requires forensic anthropologists to recognize recurring elements and, depending on the degree of fragmentation and quality of preservation, to reassociate elements that potentially originated from the same individual. The Minimum Number of Individuals (MNI) is the most widely used calculation for estimating the contents of assemblages. The MNI estimate is determined based on the most frequently occurring sided or midline element (such as right first ribs or mandibles). This tool leaves much to be desired, however, as it only seeks to estimate the number of individuals represented in the recovered assemblage, and not the original setting, which may have potentially been altered by a number of taphonomic factors. Consequently, calculations of MNI may often grossly underestimate the *true* number of individuals (Adams and Konigsberg, 2008). The Most Likely Number of Individuals (MLNI), an adaptation of the Lincoln Index used for faunal remains, often yields a much more accurate estimate than MNI by seeking to reassociate paired elements (i.e., the left and right of the same element).

Although Byrd and Adams (2009) argue that visually matching pairs based on general symmetry and overall morphological similarities is the most accurate strategy available to forensic anthropologists, effectively every individual displays asymmetry to some degree, which may complicate attempts to reassociate remains (Auerbach and Ruff, 2006; Palmer and Strobeck, 1986). Morphological asymmetry manifests in three forms: directional asymmetry, such as the heart in humans, in which a feature is consistently biased to one side or another in all organisms of a given species; antisymmetry, such as handedness, in which asymmetry occurs in all organisms but the bias is not consistent; and fluctuating asymmetry, which is a normally-distributed, random variation from the expected symmetry (Naugler and Ludman, 1996). This last form reflects a complex interaction between both genetic factors and environmental stressors. Numerous paleoanthropological and faunal studies indicate that less asymmetry is evident in the lengths and articular surfaces of long bones, as compared to highly variable diaphyseal breadths (Auerbach and Ruff, 2006). This suggests that diaphyseal measurements exhibit more environmental plasticity, due to mechanical loading and behavior, than lengths and articulating regions, which may be more controlled by genetics (Auerbach and Ruff, 2006). Despite the potential utility for commingled remains that exists in understanding the degree to which asymmetry is manifest, very little research has explored this in modern samples.

This study seeks to determine the degree of asymmetry that exists in the long bones of a modern human sample. To do this, it must first be determined whether asymmetry is, in fact, less evident in the lengths and articular surfaces of long bones, compared to diaphyseal breadths. Ultimately, this project examines directional asymmetry within limb bones to determine which regions would be the most reliable for pair matching.

Estimating the Contents of Skeletal Assemblages

In an archaeological setting, faunal analysis is undertaken to further understanding of animal procurement strategies, diet, and predator-prey relationships (Lyman, 1987). Within a forensic context, analysis of human skeletal assemblages is crucial for interpretation of peri- and post-mortem events, identification, and potentially for use during criminal trials (Adams and Konigsberg, 2008). Originally employed to quantify faunal remains, the Minimum Number of Individuals and Most Likely Number of Individuals are now widely used to quantify assemblages of human skeletal remains.

Minimum Number of Individuals (MNI)

The Minimum Number of Individuals (MNI) is the most commonly employed method for quantifying the contents of assemblages, due to both its ease of use and precedence in archaeological studies (Adams and Konigsberg, 2008). It is calculated by sorting the remains by element and side, and then using the number of the most frequently occurring element as the estimate. In the event that the remains are fragmentary, this may be done by considering specific regions of an element, such as the right humeral head, in place of the whole element. Despite the ease with which MNI may be calculated, the accuracy of its estimate is only guaranteed if all of at least one type of element is recovered. Because of loss due to taphonomic factors such as disarticulation, mechanical alteration, or scavenging, it is exceedingly rare that all of the elements originally deposited will be recovered (Lyman, 1987). MNI only estimates the number of individuals recovered from an assemblage, potentially underestimating the true scope of the represented population (Adams and Konigsberg, 2008).

The Lincoln Index and Most Likely Number of Individuals (MLNI)

The Lincoln Index (LI) was originally employed to quantify populations of living animals but later became used in analysis of zooarchaeological assemblages and then human remains (Adams and Konigsberg, 2008). Unlike the MNI calculation, the LI estimates the *original* contents of assemblages, which potentially differs from the recovered remains due to taphonomic processes like weathering, disarticulation, or scavenging. It is calculated as:

$$\mathrm{LI} = \frac{\mathrm{L \ x \ R}}{\mathrm{P}}$$

where L and R are the number of left- and right-sided elements recovered, respectively, and P is the number of reassociated pairs made from the left- and right-sided elements. A modified version of the LI was suggested by Seber (1973) and was shown by Adams and Konigsberg (2004) to provide the maximum likelihood estimate. Termed the Most Likely

Number of Individuals (MLNI), this calculation improves upon the LI by accounting for sample bias:

$$\text{MLNI} = \frac{(L+1)(R+1)}{P+1} - 1$$

The accuracy of the MLNI calculation is largely dependent on proper identification of pairs, a task that may be greatly complicated in situations of poor preserved or highly fragmented remains. To match sided elements, anthropologists rely on a suite of techniques including comparison of taphonomic alterations, general morphological similarities, seriation, and DNA testing of remains (Adams and Konigsberg, 2008; SWGANTH, 2013).

Despite the longstanding reliance on "general symmetry" as a justification for pair-matching, asymmetry results from multiple factors and variably influences different dimensions, making this "rule of thumb" suspect. More reliable pair matching and subsequent quantification of skeletal assemblages can be accomplished by prioritizing dimensions that exhibit less bilateral asymmetry. Regions that exhibit minimal bilateral asymmetry will be more consistent in size, and thus form a more reliable basis for establishing a match than the "general symmetry" guideline, which presumably places equivalent importance on dimensions that are inherently highly variable as ones that are consistent. Articular surfaces and lengths of long bones have repeatedly been shown to exhibit less asymmetry than diaphyseal dimensions, which are more plastic due to their sensitivity to environmental factors, particularly mechanical loading (Ruff et al., 1994; Trinkaus et al., 1994; Auerbach and Ruff, 2005).

Asymmetry and Human Skeletal Morphology

Deviations from perfect bilateral symmetry are common in human skeletal morphology and result from a combination of environmental factors and developmental programming (Auerbach and Ruff, 2006). Asymmetry manifests in three forms: antisymmetry; directional asymmetry; and fluctuating asymmetry. Understanding the significance of each form, and the relationship that each has with heredity and environment is a crucial step in determining how much asymmetry is to be expected in a given bone.

Antisymmetry

Antisymmetry occurs when an asymmetric trait is present in all individuals of a given population, with the biased, or overdeveloped, side varying equally amongst individuals. In male fiddler crabs, one large signaling cheliped, or claw, develops opposite a much smaller cheliped used for feeding; the more prominent claw is equally likely to develop on either the left or the right side of the crab (Pratt and McLain, 2002). While there is no definitive instance of antisymmetry in humans, handedness is a comparable analog (Naugler and Ludman, 1996).

Directional Asymmetry

Directional asymmetry reflects a character that is consistently biased to one side or another within all individuals of the same species (Palmer and Strobeck, 1986). Numerous studies have demonstrated that while skeletal elements may be subjected to the same environmental conditions, articular surfaces and lengths of long bones are less plastic than diaphyseal dimensions (Auerbach and Ruff, 2006; Ruff et al., 1994; Trinkaus et al., 1994).

The role of mechanical loading and habitual activity on skeletal asymmetry has been well documented (Auerbach and Ruff, 2006; Steele, 2000). Athletes, such as tennis or racquetball players, who engage in rigorous unilateral activity exhibit minimal asymmetry in limb lengths or articular surfaces, but the diaphyses of the more heavily used limb are significantly larger than the corresponding region on the opposing limb (Ruff et al., 1994; Trinkaus et al., 1994). In an examination of humeri from recent skeletal collections and living professional tennis players, Trinkaus et al. (1994) found consistently low levels of asymmetry within the articular breadths and lengths, but dramatically higher levels within diaphyseal midshaft and distal shaft dimensions. This trend persisted across all of the groups examined, but within the athletes, the degree of asymmetry within the diaphyseal dimensions was particularly pronounced, while leaving the lengths and articular dimensions minimally affected. Trinkaus et al. (1994) found a similar pattern within a sample of Neandertals. This indicates that moderate disparities in activity level – such as those attributed to handedness – have a low impact on articular breadths and lengths of the long bones, and potentially much greater effects on the diaphyses, while excessive unilateral movements can have even stronger implications for cross-sections of bones.

Lieberman et al. (2001) also found that diaphyses and articular surfaces respond differently to loading. In an examination of the impact of mechanical loading on articular surface areas (ASAs) of epiphyses in sheep, there was no significant difference in the ASAs of animals subjected to increased stress (in the form of running), while diaphyseal dimensions, particularly in the distal hind limbs, did increase.

The extent of bilateral asymmetry present, however, is related not just to the type and frequency of mechanical loading, but also to the developmental stage at which point this activity occurs. The periosteal surface of bone changes in response to mechanical loading occurring from childhood to early adolescence, while the endosteal surface exhibits change as a result of mechanical loading from mid-adolescence through adulthood (Ruff et al., 1994).

Human limb dimensions exhibit a unique phenomenon not seen in other primates, known as “crossed symmetry” (Auerbach and Ruff, 2006; McGrew et al., 1998). Dimensions of the upper limbs are significantly larger on the right side, but the pattern is reversed in the lower limbs, which tend to be left-biased (Plochocki 2004; Ruff et al. 1994). This directional asymmetry in the lower limb is less pronounced than that of the upper limb, and is stronger in the femur than either the tibia or fibula (Plochoki, 2004). The lower limb exhibits less directional asymmetry than the upper most likely as a result of the roughly equivalent mechanical loading incurred due to bipedal locomotion (Plochoki, 2004).

Fluctuating Asymmetry

Fluctuating asymmetry operates as “developmental noise”, in that it represents slight, environmentally stimulated deviations from bilateral symmetry. These deviations occur randomly, and without direction. Because of this, a histogram charting fluctuating asymmetry in a population (the difference between left and right side measurements) would be normally distributed, and with a mean of zero (Naugler and Ludman, 1996).

Recent scholastic interest in fluctuating asymmetry stems from a desire to understand the limits of genetic influence on deviations from bilateral symmetry (Pratt and McLain, 2002). Although moderate asymmetry shown in the articular regions and lengths, as well as some of the asymmetry of the cross-sections, could be attributed to fluctuating asymmetry, any deviations above a few percent are not likely to be caused by random stress (Trinkaus et al., 1994). Rather, morphological changes in diaphyseal dimensions are attributable to the disparity in mechanical loading between limbs.

The principle of bone functional adaptation explains the consequences of mechanical stress on bone modeling by asserting that new bone is laid down where it is needed and resorbed where it is not (Ruff et al., 2006). The apparent canalization of the articular surfaces and lengths indicates that external dimensions within those regions are less influenced by mechanical loading, at least not nearly to the degree that diaphyseal shaft dimensions are manipulated.

The purpose of this study is to first determine the amount of directional bilateral asymmetry that is likely to occur within two elements in a given dimension, and the impact this would have in attempts to reassociate left and right side elements. From there, it will be possible to determine the maximum amount of asymmetry that is likely to occur within two elements in a given dimension, and still have originated from the same individual. Dimensions that exhibit greater directional asymmetry, as well as overall asymmetry, are inherently prone to greater variation. Consequently, relying on such regions compromises the utility of any technique dependent on symmetry.

Understanding the degree of variation that is expected in a given region and element will allow anthropologists to more accurately pair-match remains bones and improve the reliability of MLNI estimates. This will also facilitate reassociation of commingled remains into discrete individuals, particularly in situations where it is not feasible to DNA test each element or fragment.

I. Materials and Methods

Sampling and Data Collection

William M. Bass Donated Skeletal Collection

Established in 1981, at the University of Tennessee's main campus in Knoxville, the William M. Bass Donated Skeletal Collection is presently the largest modern skeletal research collection in the United States. As of this writing, the Bass collection consists of over 1,000 sets of donated skeletal remains, 42 fetal and infant remains, and the cremains of 47 individuals (WM Bass Donated Skeletal Collection). The Forensic Anthropology Center (FAC), which curates the collection, requests information from donors concerning their personal history and lifestyle; the corresponding paperwork inquires as to a donor's birth year, sex, ancestry, medical and dental history, occupation, handedness, habitual activities, number of children, education, childhood socioeconomic status, and photographs (Shirley et al., 2011).

At the time of accession, each donor is given a two-part identification number, denoting his or her place in that year's sequence of donations and the donation year; for example, donor ID 14-08 would indicate that the corresponding individual was the fourteenth donation of 2008. Upon arrival at the Anthropological Research Facility, the outdoor laboratory component of the FAC, the remains are placed to decompose. Following skeletonization, the remains are collected, inventoried, and processed, at which point volunteers clean away any remaining tissue. Lastly, each element is labeled and an extensive series of osteological measurements are taken and recorded in the FAC's database.

The expansive size of the Bass Collection and its corresponding social documentation have facilitated innovative research in areas such as trauma and taphonomy, among many others. Despite its widespread use in research, the collection suffers from multiple sources of bias common in many skeletal reference collections, especially in terms of ancestry, sex, and age representation (Komar and Grivas, 2008). Over 90% of donors, both current and registered for future donation, are self-reported as white, 70% are male, and the mean age is 68 (Shirley et al., 2011; Wilson et al., 2007).

Sample Selection

The relationship between ancestry and asymmetry or sex and asymmetry in a modern population has not yet been fully explored. To avoid the potentially confounding results of a sample comprised of multiple ancestries and both sexes, this study solely utilizes males of white ancestry, the most represented demographic in the Bass Collection. Because skeletal measurements for a donor cannot be included in the database until the remains are fully skeletonized and processed, only individuals accessioned through 2010 were eligible for inclusion. A random sample was created by selecting 100 white males, beginning with the most recent donors, and excluding any donor for whom more than two of the selected bilateral measurements were undocumented (Appendix A). Due to the overrepresentation of older donors in the collection, the sample was age-balanced so that fifty individuals were younger than sixty at the time of death and fifty were sixty years or older. All of these individuals were measured by the same observer for inclusion into the database.

Measurements

Four long bones were selected for measurement and analysis: the humerus; radius; femur; and tibia. Between three and seven bilateral measurements were chosen for each of the elements, to ensure adequate evaluation of articular surface-, length-, and diaphyseal-related regions of each bone (Table 1). Each was recorded to the nearest 1.0 millimeter (mm). Lengths were measured using an osteometric board and consisted of the maximum length of the humerus (HUMXLN), maximum length of the radius (RADXLN), the maximum and bicondylar lengths of the femur (FEMXLN and FEMBLN, respectively), and the maximum length of the tibia (TIBXLN). Articular breadths included the maximum vertical diameter of the humeral head (HUMHDD), maximum diameter of the radial head (RADHDD), and maximum diameter of the femoral head (FEMHDD), and were measured using sliding calipers. Peri-articular breadths included the breadth of the upper epiphysis and the epicondylar breadth of the humerus (HUMBUE and HUMEBR, respectively), epicondylar breadth of the femur (FEMEBR), and the maximum epiphyseal breadths of the proximal and distal epiphyses of the tibia (TIBPEB and TIBDEB) were taken using the osteometric board. In the humerus, radius, and femur, diaphyseal measurements were taken at midshaft using sliding calipers. These consisted of the maximum and minimum midshaft diameters of the humerus (HUMMXD and HUMMWD), the sagittal diameter of the midshaft of the radius (RADAPD), and the sagittal and transverse midshaft diameters of the femur (FEMMAP and FEMMTV). In the tibia, maximum and transverse diameters (TIBNFX and TIBNFT) were taken at the level of the nutrient foramen.

Table 1. Definition of measurements used for this study

Element	Measurement	Instrument	Description
Humerus	Maximum length (HUMXLN)	Osteometric board	Distance from the most superior point on the humeral head to most inferior point on the trochlea (Buikstra and Ubelaker, 1994)
	Breadth of the upper epiphysis (HUMBUE)	Osteometric board	Widest distance across the upper epiphysis, including the greater tubercle (Buikstra and Ubelaker, 1994)
	Maximum diameter at midshaft (HUMMXD)	Sliding calipers	Greatest diameter, taken at the midpoint of the shaft; not necessarily oriented antero-posteriorly (Buikstra and Ubelaker, 1994)
	Minimum diameter at midshaft (HUMMWD)	Sliding calipers	Least diameter, taken at the midpoint of the shaft (Buikstra and Ubelaker, 1994)
	Maximum vertical diameter of the head (HUMHDD)	Sliding calipers	Direct distance between the most superior and inferior points of the head, at the border of the articular surface (Buikstra and Ubelaker, 1994)
	Epicondylar breadth (HUMEBR)	Osteometric board	Distance between the most laterally-projecting point of the lateral epicondyle and most medially-protruding point of the medial epicondyle (Buikstra and Ubelaker, 1994)
Radius	Maximum length (RADXLN)	Osteometric board	Distance from the most proximal point on the radial head to the most distal point, on the styloid process (Buikstra and Ubelaker, 1994)
	Maximum diameter of head (RADHDD)	Sliding calipers	Greatest diameter on the radial head, taken two opposing sides on the edge of the articular surface (Buikstra and Ubelaker, 1994)
	Sagittal diameter at midshaft (RADAPD)	Sliding calipers	Antero-posterior diameter, taken at midshaft (Buikstra and Ubelaker, 1994)
Femur	Maximum length (FEMXLN)	Osteometric board	Distance from the most superior point on femoral head to the most inferior point on the distal condyles (Buikstra and Ubelaker, 1994)
	Bicondylar length (FEMBLN)	Osteometric board	Distance from the most superior point on femoral head to a plane drawn along the inferior edges of the distal condyles (Buikstra and Ubelaker, 1994)
	Antero-posterior diameter at midshaft (sagittal) (FEMMAP)	Sliding calipers	Antero-posterior diameter, taken approximately at midshaft, at the highest elevation of the linea aspera (Buikstra and Ubelaker, 1994)
	Transverse diameter at midshaft (FEMMTV)	Sliding calipers	Distance between the medial and lateral margins of the femur, measured perpendicular to and at the same level as the antero-posterior diameter (Buikstra and Ubelaker, 1994)
	Maximum diameter of head (FEMHDD)	Sliding calipers	Maximum diameter of then femoral head measured along the border of the articular surface (Buikstra and Ubelaker, 1994)
	Epicondylar breadth (FEMEBR)	Osteometric board	Distance between the two most laterally projecting points on the epicondyles (Buikstra and Ubelaker, 1994)
	Circumference at midshaft (FEMCIR)	Measuring tape	Circumference measured at midshaft, at the same levels as the sagittal and transverse diameters (Buikstra and Ubelaker, 1994)

Table 1. Definition of measurements used for this study, continued

Element	Measurement	Instrument	Description
Tibia	Maximum Length (TIBXLN)	Osteometric board	Distance from the superior articular surface of the lateral condyle to the tip of the medial malleolus (Buikstra and Ubelaker, 1994)
	Maximum Epiphyseal Breadth, Proximal (TIBPEB)	Osteometric board	Maximum distance between the two most lateral projecting points on the medial and lateral condyles of the proximal epiphysis (Buikstra and Ubelaker, 1994)
	Maximum Epiphyseal Breadth, Distal (TIBDEB)	Osteometric board	Distance between the most medial point of the medial malleolus and the most lateral point of the distal epiphysis (Buikstra and Ubelaker, 1994)
	Maximum Diameter at Nutrient Foramen (TIBNFX)	Sliding calipers	Distance between the anterior crest and the posterior surface, taken at the level of the nutrient foramen (Buikstra and Ubelaker, 1994)
	Transverse Diameter at Nutrient Foramen (TIBNFT)	Sliding calipers	Distance between the medial margin and interosseous crest (Buikstra and Ubelaker, 1994)
	Circumference at Nutrient Foramen (TIBCIR)	Measuring tape	Circumference, taken at the level of the nutrient foramen (Buikstra and Ubelaker, 1994)

Each measurement chosen for inclusion is among a suite of measurements taken for each set of remains and recorded in the FAC database. This database is made available to researchers. Prior to their employment by the FAC, these measurements were also described in the osteological literature (Buikstra and Ubelaker, 1994; Moore-Jansen et al., 1994; Zobeck, 1983).

Statistics

Calculating Percentage Directional Asymmetry

In order to determine the relative amount of asymmetry exhibited in each element, the bilateral data for each measurement were calculated as percentage directional asymmetry (%DA) (Steele and Mays, 1995).

$$\%DA = \frac{(\text{right} - \text{left})}{(\text{average of left and right})} \times 100$$

Percentage directional asymmetry indicates directional bias in a dimension; any positive %DAs are consistent with a right-biased measurement, while negative values are indicative of a left-biased measurement (Auerbach and Ruff, 2006). This formula allows for the expression of asymmetry with respect to the size of the element being measured. Viewing the asymmetric value independently, without converting it into percentage directional asymmetry, could result in a skewed interpretation of its relative significance; for instance, a 3 mm difference between left and right sides indicates greater asymmetry in an inherently smaller dimension, like maximum diameter of the radial head, than a larger one, like maximum length of the femur (Auerbach and Ruff, 2006).

Percentage absolute asymmetry (%AA) was also calculated for each dimension, to assess the *total* amount of asymmetry present without regards to bias (Auerbach and Ruff, 2006).

$$\%AA = \frac{\text{maximum} - \text{minimum}}{(\text{average of maximum and minimum})} \times 100$$

Error Rates

Error rates for each of the measurements were determined using a subset of ten individuals, randomly selected from the 100-individual sample. Each of these ten individuals was measured twice by an additional observer on non-consecutive days (Appendix B). Mean absolute percentage error (MAPE) was used to establish intraobserver error rates, by comparing dimensions for the two sets of non-database measurements. Left and right side measurements were compared separately. Interobserver error rates were found by comparing the left and right side the database measurements to the mean of the measurements from the two non-database sets. The equation for MAPE is as follows:

$$MAPE = \frac{100}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|$$

where A is the original value, and F is the observed value.

Measurements collected for the database were taken using analog sliding calipers, and were recorded to the nearest millimeter. Because digital calipers were used to measure and re-measure the subset, the data were originally recorded to the nearest hundredth of a millimeter. To be consistent with the FAC practices and database, those measurements were rounded to the nearest millimeter using conventional rounding standards.

With the exception of one measurement (TIBNFT, left side, interobserver error), all error rates fell below 3.00% (Table 2). More than half (48 out of 88 bilateral measurements) were below 1.00%. The consistently low interobserver and intraobserver error rates suggest that the data are minimally affected by measurement error and may be reliably used for further statistical testing.

Table 2. Interobserver and Intraobserver MAPE

Element	Measurement	Intraobserver MAPE		Interobserver MAPE	
Humerus		Left	Right	Left	Right
	Maximum length	0.28	0.28	0.08	0.12
	Breadth of the upper epiphysis	1.50	1.31	1.36	1.34
	Maximum diameter at midshaft	0.45	0.40	1.28	1.95
	Minimum diameter at midshaft	0.45	0.00	1.27	1.03
	Maximum vertical diameter of the head	1.04	2.30	2.88	2.75
	Epicondylar breadth	2.35	1.27	2.41	2.65
Radius					
	Maximum length	0.24	1.10	0.14	0.16
	Maximum diameter of head	1.59	0.83	0.46	1.24
	Sagittal diameter at midshaft	0.00	0.00	1.22	0.71
Femur					
	Maximum length	0.11	0.13	0.13	0.18
	Bicondylar length	0.22	0.08	0.16	0.13
	Antero-posterior diameter at midshaft (sagittal)	0.91	1.01	1.32	1.80
	Transverse diameter at midshaft	0.79	0.45	0.50	0.86
	Maximum diameter of head	0.66	0.67	0.61	0.63
	Epicondylar breadth	1.13	1.01	0.66	0.64
	Circumference at midshaft	0.67	0.79	0.68	1.07
Tibia					
	Length	0.15	0.20	1.13	0.86
	Maximum Epiphyseal Breadth, Proximal	0.87	1.19	0.63	1.10
	Maximum Epiphyseal Breadth, Distal	1.42	1.36	1.41	1.20
	Maximum Diameter at Nutrient Foramen	1.30	3.60	0.67	2.84
	Transverse Diameter at Nutrient Foramen	2.56	0.74	3.27	2.30
	Circumference at Nutrient Foramen	0.53	0.63	1.07	0.99

Mann-Whitney U Test

Ratio and percentage data violate the assumptions of the majority of parametric statistics, necessitating the use of nonparametric tests to assess the significance of the percentage directional asymmetry (Zar, 2010). The Mann-Whitney U test is the non-parametric equivalent of the student's t-test for independent samples. A Mann-Whitney U test was conducted to determine whether there is a statistically significant difference between the directional asymmetry of the two age cohorts. If there is no difference, then the fifty individuals from each group will be pooled into one sample for further testing.

Wilcoxon Signed-Ranks Test

Because numerous studies have found articular surface dimensions to be influenced more by genetic factors than environmental, it is hypothesized that these dimensions will display less directional asymmetry; in other words, for measurements corresponding to articular surfaces, their directional asymmetry should not differ significantly from 0. Contrarily, diaphyseal dimensions have been shown to reflect the greatest amount of asymmetry, and should therefore differ significantly from 0.

For the Wilcoxon signed-rank tests, the null and alternate hypotheses are as follows:

H_0: The percentage absolute asymmetry of the tested measurement does not differ significantly from 0.

H_A: The percentage absolute asymmetry of the tested measurement differs significantly from 0.

Each %DA was converted to an absolute value, which was then compared to a median of 0, to determine the overall deviation from bilateral symmetry.

Since fluctuating asymmetry is present to some degree in all bilateral elements, and measurement error is a risk in most data collection, these factors operate as background noise and must be taken into consideration when interpreting statistical results (Merila and Biorklund, 1995). To account for and mitigate this noise, the Wilcoxon tests were performed three times, each at a different threshold of directional asymmetry: first, when %AA ≥ 0, thereby including all measurements; second, then %AA > 0.50%; and third, when %AA ≥ 1%. It was important to note whether the significance (or lack thereof) of each measurement persisted across each threshold, to determine whether the observations of absolute asymmetry were consistent when the noise of fluctuating asymmetry and slight measurement errors were reduced.

II. Results

Mann-Whitney U Test

There was a significant difference in directional asymmetry between the two age cohorts for the maximum vertical diameter of the humeral head (p = .022) and the maximum diameter of the femoral head (p = .014) (Table 3). For the remainder of the dimensions, there was no consequential difference between the two groups. Because the difference between the age groups was only significant for two measurements, the subsequent Wilcoxon signed-ranks tests were conducted three times: with a pooled sample consisting of all ages; a sample consisting of only individuals younger than 60; and a sample comprised of the individuals aged sixty or over.

Table 3
Mann-Whitney U Test Significances

Bone	Measurement	Age Grouping	N	Significance (P-value)
Humerus	Maximum length	Ages < 60	50	.583
		Ages ≥ 60	50	
	Breadth of the upper epiphysis	Ages < 60	50	.741
		Ages ≥ 60	49	
	Maximum diameter at midshaft	Ages < 60	50	.798
		Ages ≥ 60	50	
	Minimum diameter at midshaft	Ages < 60	50	.967
		Ages ≥ 60	50	
	Maximum vertical diameter of the head	Ages < 60	49	**.022***
		Ages ≥ 60	44	
	Epicondylar breadth	Ages < 60	46	.604
		Ages ≥ 60	49	
Radius	Maximum length	Ages < 60	49	.161
		Ages ≥ 60	49	
	Maximum diameter of head	Ages < 60	47	.567
		Ages ≥ 60	48	
	Sagittal diameter at midshaft	Ages < 60	49	.365
		Ages ≥ 60	50	
Femur	Maximum length	Ages < 60	50	.926
		Ages ≥ 60	48	
	Bicondylar length	Ages < 60	50	.924
		Ages ≥ 60	48	
	Antero-posterior diameter at midshaft (sagittal)	Ages < 60	50	.991
		Ages ≥ 60	50	
	Transverse diameter at midshaft	Ages < 60	50	.559
		Ages ≥ 60	50	
	Maximum diameter of head	Ages < 60	48	**.014***
		Ages ≥ 60	50	
	Epicondylar breadth	Ages < 60	48	.072
		Ages ≥ 60	49	
	Circumference at midshaft	Ages < 60	50	.614
		Ages ≥ 60	50	
Tibia	Length	Ages < 60	47	.334
		Ages ≥ 60	47	
	Maximum Epiphyseal Breadth, Proximal	Ages < 60	43	.627
		Ages ≥ 60	46	
	Maximum Epiphyseal Breadth, Distal	Ages < 60	46	.681
		Ages ≥ 60	45	
	Maximum Diameter at Nutrient Foramen	Ages < 60	50	.923
		Ages ≥ 60	50	
	Transverse Diameter at Nutrient Foramen	Ages < 60	50	.255
		Ages ≥ 60	50	
	Circumference at Nutrient Foramen	Ages < 60	49	.752
		Ages ≥ 60	47	

* denotes significance at $p < 0.05$.

Wilcoxon Signed-Ranks Test

Within the sample of pooled ages, 11 of the 22 dimensions were significant across all three levels of absolute asymmetry: in the humerus, breadth of the upper epiphysis, maximum diameter at midshaft, minimum diameter at midshaft, and epicondylar breadth; in the radius, maximum length and sagittal diameter; in the femur, transverse diameter at midshaft, maximum diameter of the head, and epicondylar breadth; and in the tibia, length, maximum diameter at the nutrient foramen, and circumference at the nutrient foramen (Table 4). Because $p < 0.05$ for each of these dimensions, the null hypothesis was rejected, indicating that the absolute asymmetries documented for each of these was significantly greater than 0. The %AA of one measurement, maximum length of the humerus, was insignificant at the lowest threshold ($p = .095$), but when only %AAs greater than 0.5% and 1.0% were considered, the value was significantly different than 0 (p = .034 and .009, respectively).

When the sample was considered as two separate age cohorts (Ages < 60 and Ages ≥ 60), there was little consistency in which measurements displayed a level of asymmetry significantly greater than 0. Using a sample comprised solely of the individuals younger than sixty for a Wilcoxon signed-ranks test, only four measurements were significant across all three thresholds of absolute asymmetry (Table 5). In the humerus, HUMBUE (p = .001, .000, and .000); HUMMXD (p = .000, .000, and .000); and HUMMWD (p = .012, .002, and .002); and in the radius, RADXLN (p = .010, .007, and .006) consistently exhibited p-values less than .05, indicating that the absolute asymmetry associated with each of these dimensions significantly deviated from 0. No dimensions from the lower long bones exhibited significant percentage absolute asymmetry.

In the younger cohort, in the HUMXLN dimension, the calculated p-value is not significant at the lowest AA threshold (p = .111), reaches significance the next threshold (p = .041), and again is not significant at the highest threshold, %AA ≥ 1% (p = .055). This "appearing and disappearing" significance is likely a statistical artifact related to increasingly smaller sample sizes and the arbitrary selection of 0.05 as the level of significance.

When the sample consisted of individuals aged 60 years or older, multiple dimensions from each of the four elements displayed significant values (Table 6). In addition to the four significant measurements from the younger cohort, HUMHDD, HUMEBR, RADAPD, FEMMTV, FEMHDD, FEMEBR, TIBNFX, and TIBCIR all reached levels of significance with values below p = 0.05. Each of those twelve dimensions featured absolute asymmetry that differed significantly from 0.

Table 4. Wilcoxon Signed-Ranks, Pooled Ages

Element	Measurement	%AA ≥ 0		%AA ≥ 0.5		%AA ≥ 1.0	
Humerus		P-value	N	P-value	N	P-value	N
	Maximum length	.095	100	**.034***	55	**.009***	22
	Breadth of the upper epiphysis	**.000***	99	**.000***	63	**.000***	63
	Maximum diameter at midshaft	**.000***	100	**.000***	70	**.000***	70
	Minimum diameter at midshaft	**.000***	100	**.000***	46	**.000***	46
	Maximum vertical diameter of the head	.086	93	.086	50	.086	50
	Epicondylar breadth	**.030***	95	**.030***	64	**.030***	64
Radius							
	Maximum length	**.000***	98	**.000***	61	**.000***	41
	Maximum diameter of head	.395	95	.395	39	.395	39
	Sagittal diameter at midshaft	**.043***	99	**.043***	32	**.043***	32
Femur							
	Maximum length	.352	98	.402	57	1.000	23
	Bicondylar length	.073	98	.155	52	.570	22
	Antero-posterior diameter at midshaft (sagittal)	.441	100	.441	60	.441	60
	Transverse diameter at midshaft	**.028***	100	**.028***	58	**.028***	58
	Maximum diameter of head	.171	98	.171	56	.171	56
	Epicondylar breadth	**.001***	97	**.001***	49	**.001***	49
	Circumference at midshaft	.214	100	.214	74	.201	72
Tibia							
	Length	**.020***	94	**.036***	50	.186	27
	Maximum Epiphyseal Breadth, Proximal	.448	89	.448	55	.448	55
	Maximum Epiphyseal Breadth, Distal	.333	91	.333	62	.333	62
	Maximum Diameter at Nutrient Foramen	**.037***	100	**.037***	78	**.037***	78
	Transverse Diameter at Nutrient Foramen	.075	100	.075	61	.075	61
	Circumference at Nutrient Foramen	**.008***	97	**.008***	82	**.005***	69

* indicates directional asymmetry is significant at $p < 0.05$.

Table 5. Wilcoxon Signed-Ranks, Ages < 60

Element	Measurement	%AA ≥ 0		%AA ≥ 0.5		%AA ≥ 1.0	
Humerus		P-value	N	P-value	N	P-value	N
	Maximum length	.111	50	**.041***	29	.055	13
	Breadth of the upper epiphysis	**.001***	50	**.000***	30	**.000***	30
	Maximum diameter at midshaft	**.000***	50	**.000***	30	**.000***	30
	Minimum diameter at midshaft	**.012***	50	**.002***	22	**.002***	22
	Maximum vertical diameter of the head	.528	49	.615	23	.615	23
	Epicondylar breadth	.497	46	.326	32	.326	32
Radius							
	Maximum length	**.010***	49	**.007***	27	**.006***	20
	Maximum diameter of head	.194	47	.194	14	.194	14
	Sagittal diameter at midshaft	.378	49	.458	17	.458	17
Femur							
	Maximum length	.775	50	.852	32	.948	18
	Bicondylar length	.416	50	.510	30	.758	17
	Antero-posterior diameter at midshaft (sagittal)	.465	50	.465	30	.465	30
	Transverse diameter at midshaft	.301	50	.301	27	.301	27
	Maximum diameter of head	.692	48	.692	23	.692	23
	Epicondylar breadth	.144	48	.144	21	.144	21
	Circumference at midshaft	.591	50	.591	40	.577	39
Tibia							
	Length	.232	47	.291	22	.530	12
	Maximum Epiphyseal Breadth, Proximal	.581	43	.581	29	.581	29
	Maximum Epiphyseal Breadth, Distal	.606	46	.618	29	.618	29
	Maximum Diameter at Nutrient Foramen	.310	50	.310	45	.310	45
	Transverse Diameter at Nutrient Foramen	.478	50	.516	29	.516	29
	Circumference at Nutrient Foramen	.118	50	.092	39	.071	31

* indicates directional asymmetry is significant at $p < 0.05$.

Table 6. Wilcoxon Signed Ranks Test Significances, Ages ≥ 60

Element	Measurement	%AA ≥ 0		%AA ≥ 0.5		%AA ≥ 1.0	
Humerus		P-value	N	P-value	N	P-value	N
	Maximum length	.442	50	.361	26	.051	9
	Breadth of the upper epiphysis	**.001***	49	**.001***	33	**.001***	33
	Maximum diameter at midshaft	**.000***	50	**.000***	40	**.000***	40
	Minimum diameter at midshaft	**.018***	50	**.018***	24	**.018***	24
	Maximum vertical diameter of the head	**.008***	44	**.008***	27	**.008***	27
	Epicondylar breadth	**.043***	49	**.043***	32	**.043***	32
Radius							
	Maximum length	**.000***	49	**.000***	34	**.002***	21
	Maximum diameter of head	.935	48	.935	25	.935	25
	Sagittal diameter at midshaft	**.013***	50	**.013***	15	**.013***	15
Femur							
	Maximum length	.328	48	.115	25	.500	5
	Bicondylar length	.109	48	.088	22	.500	5
	Antero-posterior diameter at midshaft (sagittal)	.607	50	.607	30	.607	30
	Transverse diameter at midshaft	**.027***	50	**.027***	31	**.027***	31
	Maximum diameter of head	**.007***	50	**.007***	33	**.007***	33
	Epicondylar breadth	**.002***	49	**.002***	28	**.002***	28
	Circumference at midshaft	.212	50	.212	34	.198	33
Tibia							
	Length	**.040***	47	.059	28	.233	15
	Maximum Epiphyseal Breadth, Proximal	.666	46	.666	26	.666	26
	Maximum Epiphyseal Breadth, Distal	.442	45	.442	33	.442	33
	Maximum Diameter at Nutrient Foramen	**.027***	50	**.027***	33	**.027***	33
	Transverse Diameter at Nutrient Foramen	.062	50	.062	32	.062	32
	Circumference at Nutrient Foramen	**.037***	47	**.037***	43	**.032***	38

* indicates directional asymmetry is significant at $p < 0.05$.

When the sample consisted of pooled ages, within the humeral measurements, the percentage absolute asymmetry of HUMMXD exceeded the other five dimensions (x = .032, median = .042; Table 7)

Within the sample of individuals under age 60, again, HUMMXD exhibited the greatest percentage absolute asymmetry, compared to the other dimensions (x = .032, median = .041; Table 8).

In the sample comprised of the older individuals, both the humeral and femoral measurements were significantly different. The expression of AA in the HUMMXD was similar to that expressed in the previous two samples (x = .032, median = .043; Table 9). Many of the means of femoral dimensions exhibited a left bias (excluding FEMHDD and FEMEBR).

Within each of the three samples tested, the diaphyseal midshaft dimensions consistently featured the greatest standard deviations, indicating a much wider variation from the mean than displayed in either the articular, peri-articular, or length measurements. Within the humerus, in all three samples, the HUMMXD and HUMMWD had the greatest standard deviations, followed by the articular dimension, HUMHDD, and the peri-articular dimensions, HUMBUE and HUMEBR. The maximum length, HUMXLN, consistently exhibited the smallest standard deviation. In the radius, the sagittal diameter, RADAPD, had the largest standard deviation, followed by the articular surface measurement, RADHDD, and then the length, RADXLN. The pattern continued in the femur, where the standard deviation was greatest in the two midshaft diameter measurements, FEMAPD and FEMMTV, followed by midshaft circumference, FEMCIR, the articular surface dimension, FEMHDD, the peri-articular dimension FEMEBR, and lastly the two lengths, FEMXLN and FEMBLN. In the tibia, where diaphyseal dimensions were taken not at midshaft but rather at the level of the nutrient foramen, those measurements again were most variable, with the largest standard deviation. The only departure from the pattern seen in each of the other long bones came in the sample of individuals aged sixty or older, where the peri-articular dimension TIBDEB displayed a greater standard deviation than the circumference.

Table 7. Descriptive statistics for each measurement, pooled ages

Bone	Measurement	N	Missing	Mean	Percentiles			Standard Deviation	Variance
					25th	50th	75th		
Humerus	Maximum length	100	0	.002	-.003	.000	.009	.010	.000
	Breadth of the upper epiphysis	99	1	.011	.000	.018	.020	.018	.000
	Maximum diameter at midshaft	100	0	.032	.000	.042	.066	.042	.002
	Minimum diameter at midshaft	100	0	.017	.000	.000	.051	.040	.002
	Maximum vertical diameter of the head	93	7	.004	.000	.000	.020	.021	.000
	Epicondylar breadth	95	5	.00	-.014	.000	.016	.019	.000
Radius	Maximum length	98	2	.006	.000	.006	.013	.010	.000
	Maximum diameter of head	95	5	.004	.000	.000	.034	.029	.001
	Sagittal diameter at midshaft	99	1	.009	.000	.000	.000	.043	.002
Femur	Maximum length	98	2	-.001	-.007	-.001	.004	.009	.000
	Bicondylar length	98	2	-.001	-.006	-.002	.003	.009	.000
	Antero-posterior diameter at midshaft (sagittal)	100	0	-.002	-.032	.000	.028	.033	.001
	Transverse diameter at midshaft	100	0	-.010	-.035	.000	.000	.043	.002
	Maximum diameter of head	98	2	.005	.000	.000	.020	.017	.000
	Epicondylar breadth	97	3	.004	.000	.000	.012	.010	.000
	Circumference at midshaft	100	0	-.003	-.012	.000	.011	.021	.000
Tibia	Length	94	6	.002	-.003	.000	.008	.009	.000
	Maximum Epiphyseal Breadth, Proximal	89	11	-.001	-.012	.000	.012	.015	.000
	Maximum Epiphyseal Breadth, Distal	91	9	.003	-.019	.000	.019	.026	.001
	Maximum Diameter at Nutrient Foramen	100	0	.010	-.027	.000	.030	.041	.002
	Transverse Diameter at Nutrient Foramen	100	0	.009	.000	.000	.039	.042	.002
	Circumference at Nutrient Foramen	96	4	.006	-.010	.005	.022	.023	.001

Table 8. Descriptive statistics for each measurement, Ages < 60

Bone	Measurement	N	Missing	Mean	Percentiles			Standard Deviation	Variance
					25th	50th	75th		
Humerus	Maximum length	50	0	.003	-.003	.001	.009	.011	.000
	Breadth of the upper epiphysis	50	0	.010	.000	.000	.020	.018	.000
	Maximum diameter at midshaft	50	0	.032	.000	.041	.047	.038	.001
	Minimum diameter at midshaft	50	0	.016	.000	.000	.054	.039	.002
	Maximum vertical diameter of the head	49	1	-.002	-.019	.000	.000	.018	.000
	Epicondylar breadth	46	4	.004	-.015	.000	.016	.020	.000
Radius	Maximum length	49	1	.004	-.002	.004	.014	.010	.000
	Maximum diameter of head	47	3	.006	.000	.000	.000	.025	.001
	Sagittal diameter at midshaft	49	1	.005	.000	.000	.000	.046	.002
Femur	Maximum length	50	0	-.001	-.006	.000	.006	.010	.000
	Bicondylar length	50	0	-.001	-.008	-.002	.005	.010	.000
	Antero-posterior diameter at midshaft (sagittal)	50	0	-.002	-.032	.000	.029	.031	.001
	Transverse diameter at midshaft	50	0	-.005	-.034	.000	.000	.038	.001
	Maximum diameter of head	48	2	.000	-.015	.000	.000	.016	.000
	Epicondylar breadth	48	2	.003	.000	.000	.012	.011	.000
	Circumference at midshaft	50	0	-.001	-.012	.000	.011	.018	.000
Tibia	Length	47	3	.001	-.003	.000	.005	.008	.000
	Maximum Epiphyseal Breadth, Proximal	43	7	-.001	-.013	.000	.012	.015	.000
	Maximum Epiphyseal Breadth, Distal	46	4	.003	-.020	.000	.019	.024	.001
	Maximum Diameter at Nutrient Foramen	50	0	.010	-.030	.025	.050	.048	.002
	Transverse Diameter at Nutrient Foramen	50	0	.005	.000	.000	.038	.041	.002
	Circumference at Nutrient Foramen	49	1	.006	-.011	.000	.022	.024	.001

Table 9. Descriptive statistics for each measurement, Ages ≥ 60

Bone	Measurement	N	Missing	Mean	Percentiles			Standard Deviation	Variance
					25th	50th	75th		
Humerus	Maximum length	50	0	.001	-.004	.000	.006	.008	.000
	Breadth of the upper epiphysis	49	1	.012	.000	.018	.019	.019	.000
	Maximum diameter at midshaft	50	0	.032	.000	.043	.078	.046	.002
	Minimum diameter at midshaft	50	0	.018	.000	.000	.051	.041	.002
	Maximum vertical diameter of the head	44	6	.010	.000	.000	.021	.022	.001
	Epicondylar breadth	49	1	.005	.000	.000	.016	.019	.000
Radius	Maximum length	49	1	.007	.000	.008	.012	.010	.000
	Maximum diameter of head	48	2	.002	.000	.000	.039	.032	.001
	Sagittal diameter at midshaft	50	0	.014	.000	.000	.016	.038	.001
Femur	Maximum length	48	2	-.001	-.007	-.002	.004	.007	.000
	Bicondylar length	48	2	-.001	-.006	-.002	.002	.007	.000
	Antero-posterior diameter at midshaft (sagittal)	50	0	-.001	-.032	.000	.028	.036	.001
	Transverse diameter at midshaft	50	0	-.014	-.035	.000	.000	.047	.002
	Maximum diameter of head	50	0	.009	.000	.019	.021	.017	.000
	Epicondylar breadth	49	1	.005	.000	.000	.012	.009	.000
	Circumference at midshaft	50	0	-.005	-.012	.000	.011	.024	.001
Tibia	Length	47	3	.003	-.003	.003	.008	.010	.000
	Maximum Epiphyseal Breadth, Proximal	46	4	-.002	-.012	.000	.012	.016	.000
	Maximum Epiphyseal Breadth, Distal	45	5	.002	-.019	.000	.020	.029	.001
	Maximum Diameter at Nutrient Foramen	50	0	.011	.000	.000	.029	.035	.001
	Transverse Diameter at Nutrient Foramen	50	0	.013	.000	.000	.041	.043	.002
	Circumference at Nutrient Foramen	47	3	.007	-.010	.009	.022	.021	.000

III. Discussion

Implications for sorting commingled remains

Patterns of asymmetry demonstrated in the samples from the Bass Donated Skeletal Collection are largely consistent with earlier asymmetry studies, with only a few exceptions. The impact of mechanical loading on diaphyseal cross-sections was well documented in earlier literature, and in each of the four bones, diaphyseal shaft dimensions exhibited the greatest asymmetry articular, indicating that that shaft cross-sections are the more responsive to exogenous factors than other regions. Peri-articular, and length dimensions demonstrated significantly less directional asymmetry.

The inconsistency of bilateral measurements within different skeletal elements and dimensions necessitates a more reliable means of pair matching than the old standby, "general symmetry". In order to form more accurate matches, anthropologists must consider regions of elements that typically have low levels of bilateral variability, like articular surfaces and lengths. This can easily be operationalized using the known means of directional asymmetry for a given dimension plus or minus two standard deviations.

Standard deviation is an expression of a value's deviation from the mean. The greater the standard deviation, the more dispersal from the mean is exhibited within a group of values. In a normally distributed sample, such as the ones used for this study, approximately 68% of the population falls within one standard deviation of the mean, 95% fall within two, and nearly 99% fall within three. By examining the standard deviations associated with the percentage directional asymmetries of each of the dimensions, it is possible to determine which measurements vary the greatest and least from the mean

%DAs, and therefore, how much deviation is reasonable before two elements can be classified as, or excluded from being, a matched pair. Using the %DA means, plus or minus two standard deviations indicates what level of directional asymmetry should be seen within 95% of a population.

Shaft dimensions are more responsive to environmental influences, resulting in greater directional asymmetry (Figure 1; Figure 2). Conversely, articular surface areas and lengths are constrained by genetic factors, exhibiting less directional asymmetry. In the pooled ages sample, this is particularly evident within the radius, femur, and tibia; in the humerus, however, all of the dimensions exhibited a significant level of asymmetry with the exception of HUMHDD.

As shaft measurements displayed the greatest variability bilaterally, followed in most elements by lengths, it is crucial that when attempting to pair match two elements, anthropologists do not place excessive importance on the overall similarities in these areas alone. Heavy reliance on one side of the body over another and certain habitual activities result in greater disparity between left and right side shaft and length measurements, which suggests that any pairs matched solely on the basis of similarity between sides in those regions may be inaccurate. Rather, anthropologists must place a greater emphasis on more genetically constrained regions that will display less directional asymmetry, such as articular surfaces.

Because the upper limb exhibits markedly more asymmetry than the lower limb and the dimensions within the former vary distinctly and predictably from one another, pair matching elements based on the symmetry of the more genetically constrained regions is a much more viable technique in the arm than in the leg. In practice, the small amount of

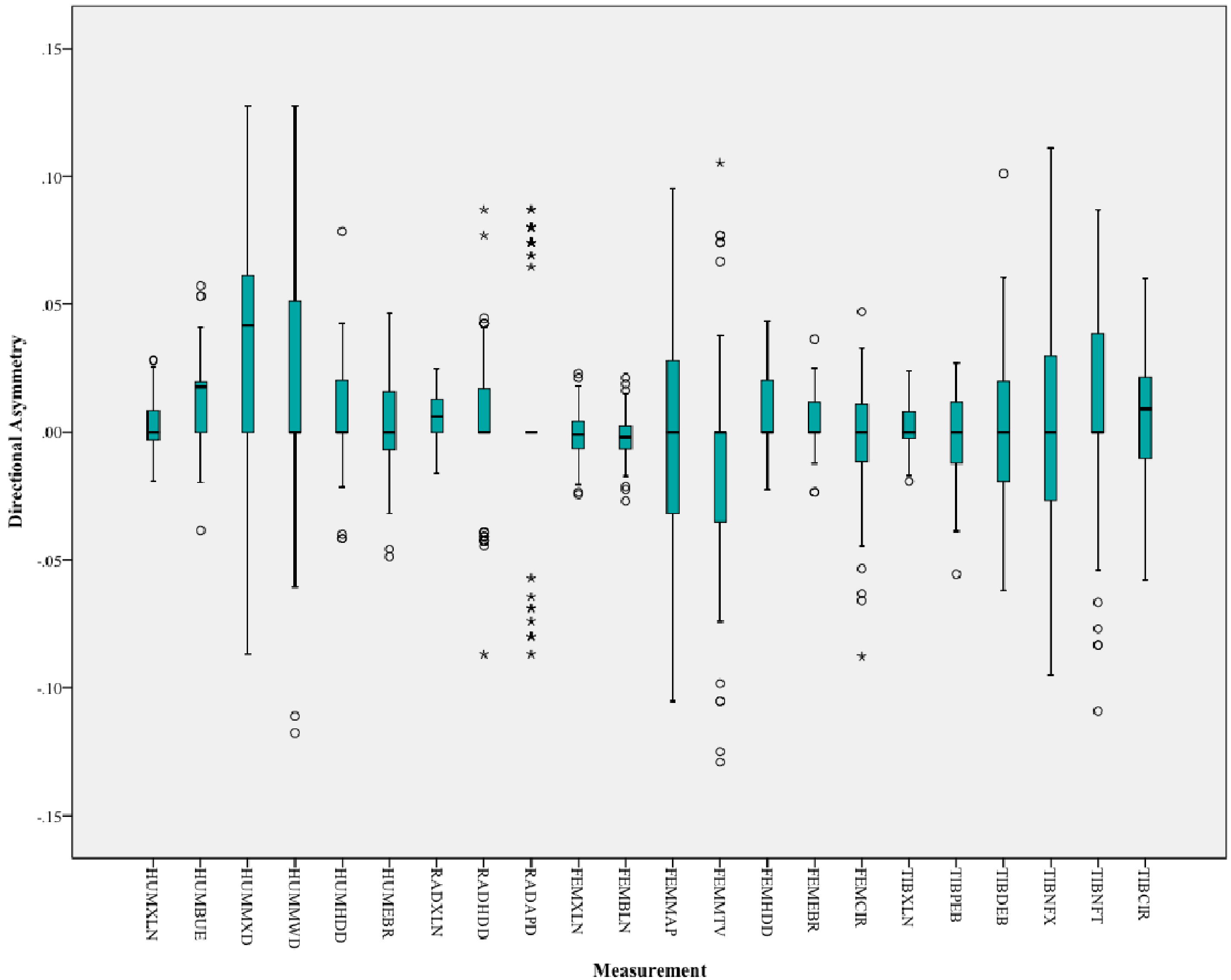

Figure 1: Boxplot displaying the directional asymmetry of each measurement, for the pooled age sample.

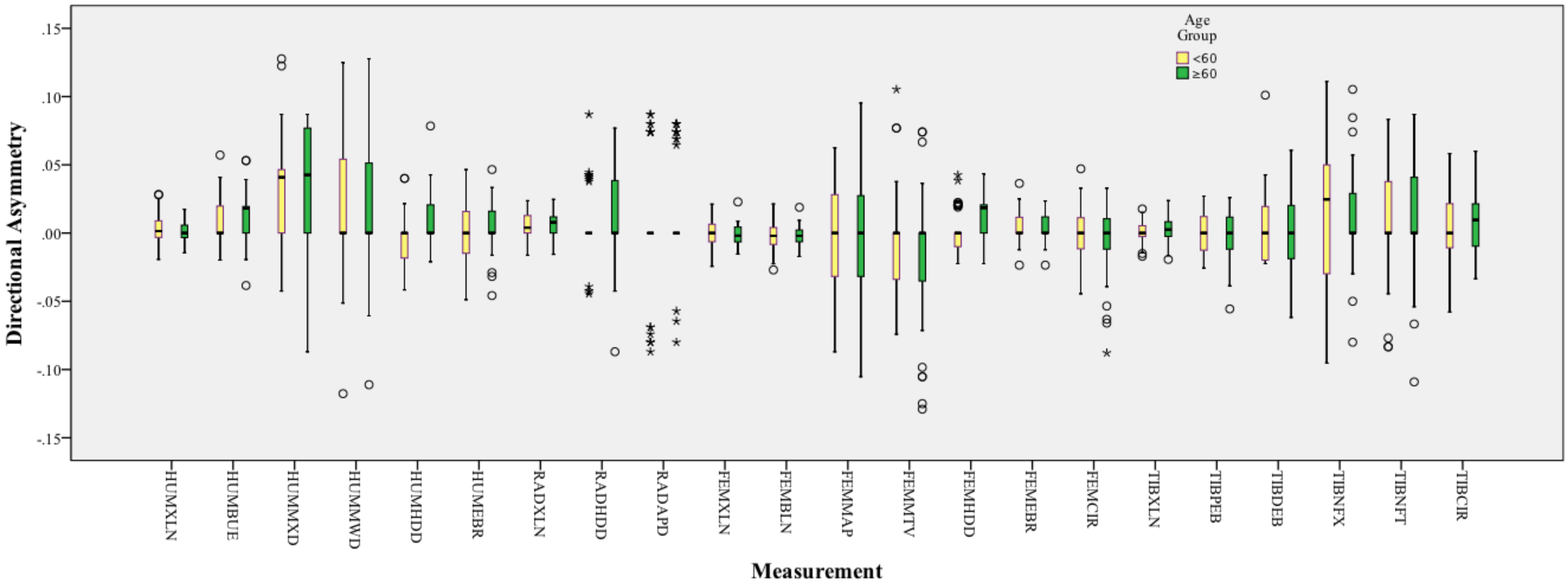

Figure 2: Boxplot comparing the directional asymmetries of each measurement between the two age cohorts.

directional asymmetry documented within the lower limb may be so small as to render it an impractical means of including or excluding elements from a pair. This is because factors such as measurement error, intra- and interobserver error, and fluctuating asymmetry may obfuscate the differences in lower limb dimensions. Instead of relying on bilateral symmetry to facilitate pair matches in the lower limb, anthropologists should employ one of the other methods currently recognized in SWGANTH's best practice guidelines for resolving commingled human remains, including articulation, process of elimination, and taphonomy (SWGANTH, 2013).

Considerations for future research

Building upon this understanding of asymmetry patterns in the humerus, radius, femur, and tibia, this data can facilitate pair matching of commingled remains. When attempting to match left and right humeri and radii, anthropologists must consider the respective lengths and articular surfaces more prominently than dimensions of the shaft. The plasticity exhibited within the diaphyses of long bones makes them inherently less predictable dimensions. Anthropologists may reasonably expect to find greater disparity in shaft diameter between left and right sided elements belonging to the same individual, than would be exhibited within the lengths and articular surface dimensions.

In future studies, the relationships between asymmetry and age, sex, and ancestry must be further explored, in order to construct a more broadly applicable model for reassociating bilateral elements. It is possible that age-related osteological issues (such as lipping caused by osteoarthritis) resulted in greater directional asymmetry in the older age group, subsequently leading to skewed results when the two age groups were pooled. In this study, measures were taken to ensure that bony growths did not skew the data, but for practical applications it may be necessary to understand the extent that these prominences affect interpretations of asymmetry. Future studies should give particular care to this issue, to ensure that age-related changes do not confound the effects of asymmetry, while paying heed to the understanding that such degenerative changes are inevitable.

Conclusion and Recommendations

A number of the results from the statistical tests are consistent with earlier studies that found greater directional asymmetry in diaphyseal measurements and less amongst articular surfaces and lengths. However, the disparity in the asymmetry of certain measurements between the age cohorts suggests that age may play a greater factor in directional asymmetry than previously assumed. The humeral and femoral dimensions seem most susceptible to age-related disparities in directional asymmetry.

The discrepancy in degree of asymmetry between the two age cohorts is likely secular change attributable, at least in part, to increasingly sedentary lifestyles. While the FAC does note career and habitual activity for most donors, this information was not incorporated into this study. As mechanical loading can influence asymmetry between elements, understanding the lifestyle of the individuals studied may prove beneficial in explaining the degree of variation present in some of the bones, particularly within the upper limb.

When attempting to differentiate commingled remains into individual sets, an understanding of the likely ages of the decedents may prove beneficial. Because the DAs of the humeral and femoral head measurements differed significantly between the age groups, any attempt to pair left and right humeri and femora should not rely solely on the quantification of asymmetry in these measurements. Instead, anthropologists should consider other dimensions within those bones as well to increase the likelihood of a correct match.

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Appendices

Appendix A: Database-derived measurements for complete sample

YEAR	UTID	AGE	HUMXLNL	HUMXLNR	Mean	%DA	ABS	BUEL	BUER	Mean	%DA	ABS	YEAR
2006	UT65-06	31	362	362	362	0	0	53	55	54	0.03703704	0.03703704	2006
2009	UT92-09	33	344	345	344.5	0.00290276	0.00290276	50	51	50.5	0.01980198	0.01980198	2009
2001	UT32-01	33	311	310	310.5	-0.0032206	0.00322061	55	55	55	0	0	2001
2007	UT50-07	38	313	316	314.5	0.00953895	0.00953895	49	49	49	0	0	2007
2008	UT100-08	39	342	340	341	-0.0058651	0.0058651	51	51	51	0	0	2008
2006	UT47-06	39	350	352	351	0.00569801	0.00569801	50	50	50	0	0	2006
2008	UT15-08	39	326	323	324.5	-0.009245	0.00924499	52	52	52	0	0	2008
2006	UT70-06	42	311	312	311.5	0.00321027	0.00321027	53	53	53	0	0	2006
2008	UT104-08	43	336	339	337.5	0.00888889	0.00888889	57	58	57.5	0.0173913	0.0173913	2008
2006	UT63-06	43	309	312	310.5	0.00966184	0.00966184	50	51	50.5	0.01980198	0.01980198	2006
2006	UT64-06	43	341	340	340.5	-0.0029369	0.00293686	53	53	53	0	0	2006
2007	UT89-07	43	324	321	322.5	-0.0093023	0.00930233	51	51	51	0	0	2007
2006	UT49-06	44	347	344	345.5	-0.0086831	0.00868307	50	50	50	0	0	2006
2007	UT114-07	44	322	323	322.5	0.00310078	0.00310078	48	50	49	0.04081633	0.04081633	2007
2007	UT53-07	44	330	331	330.5	0.00302572	0.00302572	52	53	52.5	0.01904762	0.01904762	2007
2007	UT53-07	44	330	331	330.5	0.00302572	0.00302572	48	48	48	0	0	2007
2005	UT81-05	45	348	343	345.5	-0.0144718	0.01447178	48	49	48.5	0.02061856	0.02061856	2005
2008	UT07-08	46	336	331	333.5	-0.0149925	0.0149925	51	54	52.5	0.05714286	0.05714286	2008
2004	UT73-04	46	320	327	323.5	0.02163833	0.02163833	52	52	52	0	0	2004
2006	UT46-06	46	353	354	353.5	0.00282885	0.00282885	53	55	54	0.03703704	0.03703704	2006
2007	UT107-0	46	291	291	291	0	0	52	54	53	0.03773585	0.03773585	2007
2007	UT11-07	47	294	293	293.5	-0.0034072	0.00340716	52	53	52.5	0.01904762	0.01904762	2007
2007	UT29-07	49	320	321	320.5	0.00312012	0.00312012	55	54	54.5	-0.0183486	0.01834862	2007
2006	UT08-06	50	355	355	355	0	0	51	52	51.5	0.01941748	0.01941748	2006
2008	UT49-08	50	331	331	331	0	0	51	53	52	0.03846154	0.03846154	2008
2007	UT83-07	50	334	333	333.5	-0.0029985	0.0029985	49	50	49.5	0.02020202	0.02020202	2007
2007	UT38-07	51	345	349	347	0.01152738	0.01152738	50	51	50.5	0.01980198	0.01980198	2007
2008	UT04-08	51	337	335	336	-0.0059524	0.00595238	55	56	55.5	0.01801802	0.01801802	2008
2007	UT116-07	53	313	311	312	-0.0064103	0.00641026	53	53	53	0	0	2007
2005	UT78-05	53	336	339	337.5	0.00888889	0.00888889	51	53	52	0.03846154	0.03846154	2005
2008	UT05-08	53	367	360	363.5	-0.0192572	0.01925722	55	54	54.5	-0.0183486	0.01834862	2008
2007	UT12-07	53	349	358	353.5	0.02545969	0.02545969	53	54	53.5	0.01869159	0.01869159	2007
2007	UT63-07	53	326	333	329.5	0.02124431	0.02124431	52	52	52	0	0	2007
2007	UT99-07	54	315	319	317	0.0126183	0.0126183	51	50	50.5	-0.019802	0.01980198	2007
2007	UT21-07	54	317	326	321.5	0.02799378	0.02799378	54	53	53.5	-0.0186916	0.01869159	2007
2007	UT58-07	54	314	323	318.5	0.02825746	0.02825746	58	58	58	0	0	2007
2007	UT88-07	54	301	305	303	0.01320132	0.01320132	50	51	50.5	0.01980198	0.01980198	2007
2007	UT110-07	54	357	354	355.5	-0.0084388	0.00843882	54	54	54	0	0	2007
2008	UT117-08	54	312	311	311.5	-0.0032103	0.00321027	51	50	50.5	-0.019802	0.01980198	2008
2006	UT80-06	55	343	346	344.5	0.00870827	0.00870827	51	51	51	0	0	2006
2005	UT72-05	55	326	328	327	0.00611621	0.00611621	51	53	52	0.03846154	0.03846154	2005
2008	UT18-08	56	335	338	336.5	0.0089153	0.0089153	52	52	52	0	0	2008
2006	UT34-06	56	331	330	330.5	-0.0030257	0.00302572	52	53	52.5	0.01904762	0.01904762	2006
2006	UT43-06	57	317	317	317	0	0	53	53	53	0	0	2006
2006	UT72-06	57	360	359	359.5	-0.0027816	0.00278164	51	51	51	0	0	2006
2008	UT30-08	58	336	334	335	-0.0059701	0.00597015	53	53	53	0	0	2008
2006	UT19-06	59	353	361	357	0.02240896	0.02240896	56	57	56.5	0.01769912	0.01769912	2006
2007	UT46-07	59	354	358	356	0.01123596	0.01123596	52	51	51.5	-0.0194175	0.01941748	2007
2007	UT73-07	59	351	350	350.5	-0.0028531	0.00285307	49	50	49.5	0.02020202	0.02020202	2007
2002	UT07-02	59	329	328	328.5	-0.0030441	0.00304414	53	54	53.5	0.01869159	0.01869159	2002

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	HUMXLNL	HUMXLNR	Mean	%DA	ABS	BUEL	BUER	Mean	%DA	ABS
2007	UT48-07	60	329	329	329	0	0	55	56	55.5	0.01801802	0.01801802
2006	UT97-06	61	338	336	337	-0.0059347	0.00593472	54	53	53.5	-0.0186916	0.01869159
2007	UT36-07	61	330	330	330	0	0	50	50	50	0	0
2004	UT63-04	61	345	348	346.5	0.00865801	0.00865801	51	52	51.5	0.01941748	0.01941748
2007	UT64-07	61	299	300	299.5	0.0033389	0.0033389	55	56	55.5	0.01801802	0.01801802
2006	UT50-06	62	334	331	332.5	-0.0090226	0.00902256	54	55	54.5	0.01834862	0.01834862
2005	UT70-05	62	320	320	320	0	0	56	56	56	0	0
2006	UT86-06	62	307	304	305.5	-0.00982	0.00981997	50	50	50	0	0
2007	UT65-07	63	314	315	314.5	0.00317965	0.00317965	57	57	57	0	0
2006	UT31-06	63	367	368	367.5	0.00272109	0.00272109	53	53	53	0	0
2005	UT73-05	63	363	363	363	0	0	52	53	52.5	0.01904762	0.01904762
2007	UT43-07	64	348	345	346.5	-0.008658	0.00865801	55	55	55	0	0
2007	UT87-07	64	356	359	357.5	0.00839161	0.00839161	56	57	56.5	0.01769912	0.01769912
2008	UT14-08	64	336	336	336	0	0	52	51	51.5	-0.0194175	0.01941748
2008	UT53-08	65	323	321	322	-0.0062112	0.00621118	51	52	51.5	0.01941748	0.01941748
2007	UT103-0	66	336	333	334.5	-0.0089686	0.00896861					
2008	UT118-08	67	307	312	309.5	0.01615509	0.01615509	49	50	49.5	0.02020202	0.02020202
2006	UT35-06	67	336	335	335.5	-0.0029806	0.00298063	53	51	52	-0.0384615	0.03846154
2007	UT22-07	67	317	316	316.5	-0.0031596	0.00315956	50	52	51	0.03921569	0.03921569
2005	UT89-05	68	337	338	337.5	0.00296296	0.00296296	50	51	50.5	0.01980198	0.01980198
2007	UT85-07	68	311	312	311.5	0.00321027	0.00321027	55	57	56	0.03571429	0.03571429
2007	UT104-0	68	319	320	319.5	0.00312989	0.00312989	53	52	52.5	-0.0190476	0.01904762
2008	UT38-08	69	326	328	327	0.00611621	0.00611621	51	51	51	0	0
2008	UT39-08	70	358	364	361	0.0166205	0.0166205	55	55	55	0	0
2007	UT42-07	70	319	322	320.5	0.00936037	0.00936037	53	54	53.5	0.01869159	0.01869159
2006	UT16-06	70	332	330	331	-0.0060423	0.0060423	53	55	54	0.03703704	0.03703704
2008	UT09-08	70	338	338	338	0	0	52	52	52	0	0
2006	UT103-06	71	346	352	349	0.01719198	0.01719198	51	51	51	0	0
2007	UT84-07	71	353	352	352.5	-0.0028369	0.00283688	52	51	51.5	-0.0194175	0.01941748
2006	UT01-06	71	320	321	320.5	0.00312012	0.00312012	55	55	55	0	0
2006	UT76-06	71	330	334	332	0.01204819	0.01204819	53	54	53.5	0.01869159	0.01869159
2006	UT07-06	71	344	346	345	0.0057971	0.0057971	49	49	49	0	0
2008	UT34-08	72	330	335	332.5	0.01503759	0.01503759	53	54	53.5	0.01869159	0.01869159
2003	UT64-03	72	320	318	319	-0.0062696	0.00626959	55	56	55.5	0.01801802	0.01801802
2007	UT49-07	73	342	343	342.5	0.00291971	0.00291971	52	53	52.5	0.01904762	0.01904762
2007	UT47-07	74	342	348	345	0.0173913	0.0173913	52	53	52.5	0.01904762	0.01904762
2008	UT01-08	77	326	322	324	-0.0123457	0.01234568	52	54	53	0.03773585	0.03773585
2008	UT65-08	78	315	314	314.5	-0.0031797	0.00317965	52	53	52.5	0.01904762	0.01904762
2007	UT72-07	79	367	365	366	-0.0054645	0.00546448	55	55	55	0	0
2007	UT02-07	80	343	348	345.5	0.01447178	0.01447178	51	52	51.5	0.01941748	0.01941748
2008	UT42-08	80	338	340	339	0.00589971	0.00589971	53	54	53.5	0.01869159	0.01869159
2008	UT90-08	81	301	300	300.5	-0.0033278	0.00332779	51	51	51	0	0
2007	UT06-07	81	335	332	333.5	-0.0089955	0.0089955	51	53	52	0.03846154	0.03846154
2006	UT71-06	81	345	347	346	0.00578035	0.00578035	56	56	56	0	0
2008	UT103-08	82	363	362	362.5	-0.0027586	0.00275862	52	53	52.5	0.01904762	0.01904762
2008	UT46-08	82	316	316	316	0	0	55	58	56.5	0.05309735	0.05309735
2004	UT65-04	82	323	322	322.5	-0.0031008	0.00310078	58	60	59	0.03389831	0.03389831
2008	UT114-08	82	346	341	343.5	-0.014556	0.01455604	55	58	56.5	0.05309735	0.05309735
2006	UT82-06	84	321	321	321	0	0	51	52	51.5	0.01941748	0.01941748
2006	UT13-06	90	340	341	340.5	0.00293686	0.00293686	50	50	50	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	HUMMXDL	HUMMXDR	Mean	%DA	ABS	HUMMWDL	HUMMWDR	Mean	%DA	ABS
2006	UT65-06	31	21	22	21.5	0.04651163	0.04651163	15	15	15	0	0
2009	UT92-09	33	24	24	24	0	0	19	19	19	0	0
2001	UT32-01	33	23	24	23.5	0.04255319	0.04255319	18	19	18.5	0.05405405	0.05405405
2007	UT50-07	38	23	23	23	0	0	19	19	19	0	0
2008	UT100-08	39	22	22	22	0	0	16	17	16.5	0.06060606	0.06060606
2006	UT47-06	39	23	24	23.5	0.04255319	0.04255319	17	18	17.5	0.05714286	0.05714286
2008	UT15-08	39	24	25	24.5	0.04081633	0.04081633	18	19	18.5	0.05405405	0.05405405
2006	UT70-06	42	24	25	24.5	0.04081633	0.04081633	18	18	18	0	0
2008	UT104-08	43	22	24	23	0.08695652	0.08695652	20	20	20	0	0
2006	UT63-06	43	21	22	21.5	0.04651163	0.04651163	18	18	18	0	0
2006	UT64-06	43	21	21	21	0	0	19	19	19	0	0
2007	UT89-07	43	22	22	22	0	0	19	19	19	0	0
2006	UT49-06	44	21	22	21.5	0.04651163	0.04651163	18	19	18.5	0.05405405	0.05405405
2007	UT114-07	44	24	23	23.5	-0.0425532	0.04255319	20	21	20.5	0.04878049	0.04878049
2007	UT53-07	44	23	24	23.5	0.04255319	0.04255319	21	20	20.5	-0.0487805	0.04878049
2007	UT53-07	44	22	22	22	0	0	18	19	18.5	0.05405405	0.05405405
2005	UT81-05	45	23	23	23	0	0	18	19	18.5	0.05405405	0.05405405
2008	UT07-08	46	25	25	25	0	0	18	18	18	0	0
2004	UT73-04	46	20	20	20	0	0	17	17	17	0	0
2006	UT46-06	46	22	23	22.5	0.04444444	0.04444444	15	17	16	0.125	0.125
2007	UT107-0	46	23	24	23.5	0.04255319	0.04255319	16	17	16.5	0.06060606	0.06060606
2007	UT11-07	47	24	26	25	0.08	0.08	18	18	18	0	0
2007	UT29-07	49	25	26	25.5	0.03921569	0.03921569	16	16	16	0	0
2006	UT08-06	50	23	25	24	0.08333333	0.08333333	19	19	19	0	0
2008	UT49-08	50	22	22	22	0	0	18	19	18.5	0.05405405	0.05405405
2007	UT83-07	50	24	24	24	0	0	17	17	17	0	0
2007	UT38-07	51	23	23	23	0	0	19	19	19	0	0
2008	UT04-08	51	23	24	23.5	0.04255319	0.04255319	21	22	21.5	0.04651163	0.04651163
2007	UT116-07	53	22	23	22.5	0.04444444	0.04444444	17	17	17	0	0
2005	UT78-05	53	25	25	25	0	0	17	18	17.5	0.05714286	0.05714286
2008	UT05-08	53	24	25	24.5	0.04081633	0.04081633	20	20	20	0	0
2007	UT12-07	53	23	23	23	0	0	20	20	20	0	0
2007	UT63-07	53	23	25	24	0.08333333	0.08333333	19	19	19	0	0
2007	UT99-07	54	22	22	22	0	0	21	21	21	0	0
2007	UT21-07	54	25	25	25	0	0	18	18	18	0	0
2007	UT58-07	54	25	25	25	0	0	19	20	19.5	0.05128205	0.05128205
2007	UT88-07	54	19	20	19.5	0.05128205	0.05128205	19	19	19	0	0
2007	UT110-07	54	22	23	22.5	0.04444444	0.04444444	19	19	19	0	0
2008	UT117-08	54	22	23	22.5	0.04444444	0.04444444	18	18	18	0	0
2006	UT80-06	55	23	25	24	0.08333333	0.08333333	19	19	19	0	0
2005	UT72-05	55	25	27	26	0.07692308	0.07692308	21	20	20.5	-0.0487805	0.04878049
2008	UT18-08	56	23	25	24	0.08333333	0.08333333	19	20	19.5	0.05128205	0.05128205
2006	UT34-06	56	23	23	23	0	0	17	18	17.5	0.05714286	0.05714286
2006	UT43-06	57	22	23	22.5	0.04444444	0.04444444	19	20	19.5	0.05128205	0.05128205
2006	UT72-06	57	23	26	24.5	0.12244898	0.12244898	16	17	16.5	0.06060606	0.06060606
2008	UT30-08	58	24	26	25	0.08	0.08	17	17	17	0	0
2006	UT19-06	59	21	21	21	0	0	18	18	18	0	0
2007	UT46-07	59	24	24	24	0	0	18	16	17	-0.1176471	0.11764706
2007	UT73-07	59	24	23	23.5	-0.0425532	0.04255319	19	19	19	0	0
2002	UT07-02	59	22	25	23.5	0.12765957	0.12765957	20	19	19.5	-0.0512821	0.05128205

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	HUMMXDL	HUMMXDR	Mean	%DA	ABS	HUMMWDL	HUMMWDR	Mean	%DA	ABS
2007	UT48-07	60	25	26	25.5	0.03921569	0.03921569	19	20	19.5	0.05128205	0.05128205
2006	UT97-06	61	22	23	22.5	0.04444444	0.04444444	20	20	20	0	0
2007	UT36-07	61	22	24	23	0.08695652	0.08695652	18	18	18	0	0
2004	UT63-04	61	24	26	25	0.08	0.08	19	19	19	0	0
2007	UT64-07	61	27	26	26.5	-0.0377358	0.03773585	20	21	20.5	0.04878049	0.04878049
2006	UT50-06	62	25	25	25	0	0	20	20	20	0	0
2005	UT70-05	62	27	29	28	0.07142857	0.07142857	19	19	19	0	0
2006	UT86-06	62	24	23	23.5	-0.0425532	0.04255319	18	19	18.5	0.05405405	0.05405405
2007	UT65-07	63	24	24	24	0	0	17	18	17.5	0.05714286	0.05714286
2006	UT31-06	63	22	22	22	0	0	22	25	23.5	0.12765957	0.12765957
2005	UT73-05	63	24	26	25	0.08	0.08	17	17	17	0	0
2007	UT43-07	64	22	24	23	0.08695652	0.08695652	18	18	18	0	0
2007	UT87-07	64	22	23	22.5	0.04444444	0.04444444	18	19	18.5	0.05405405	0.05405405
2008	UT14-08	64	23	25	24	0.08333333	0.08333333	18	18	18	0	0
2008	UT53-08	65	24	24	24	0	0	19	19	19	0	0
2007	UT103-0	66	22	23	22.5	0.04444444	0.04444444	21	21	21	0	0
2008	UT118-08	67	22	23	22.5	0.04444444	0.04444444	19	19	19	0	0
2006	UT35-06	67	23	24	23.5	0.04255319	0.04255319	18	18	18	0	0
2007	UT22-07	67	24	25	24.5	0.04081633	0.04081633	21	22	21.5	0.04651163	0.04651163
2005	UT89-05	68	23	24	23.5	0.04255319	0.04255319	17	16	16.5	-0.0606061	0.06060606
2007	UT85-07	68	24	25	24.5	0.04081633	0.04081633	19	19	19	0	0
2007	UT104-0	68	23	23	23	0	0	19	19	19	0	0
2008	UT38-08	69	24	26	25	0.08	0.08	17	18	17.5	0.05714286	0.05714286
2008	UT39-08	70	25	23	24	-0.0833333	0.08333333	18	19	18.5	0.05405405	0.05405405
2007	UT42-07	70	24	25	24.5	0.04081633	0.04081633	21	22	21.5	0.04651163	0.04651163
2006	UT16-06	70	23	23	23	0	0	21	22	21.5	0.04651163	0.04651163
2008	UT09-08	70	22	23	22.5	0.04444444	0.04444444	21	21	21	0	0
2006	UT103-06	71	25	27	26	0.07692308	0.07692308	20	21	20.5	0.04878049	0.04878049
2007	UT84-07	71	26	27	26.5	0.03773585	0.03773585	18	18	18	0	0
2006	UT01-06	71	24	26	25	0.08	0.08	18	17	17.5	-0.0571429	0.05714286
2006	UT76-06	71	26	26	26	0	0	18	19	18.5	0.05405405	0.05405405
2006	UT07-06	71	24	26	25	0.08	0.08	19	19	19	0	0
2008	UT34-08	72	24	23	23.5	-0.0425532	0.04255319	20	21	20.5	0.04878049	0.04878049
2003	UT64-03	72	22	23	22.5	0.04444444	0.04444444	19	21	20	0.1	0.1
2007	UT49-07	73	25	26	25.5	0.03921569	0.03921569	19	19	19	0	0
2007	UT47-07	74	24	26	25	0.08	0.08	17	18	17.5	0.05714286	0.05714286
2008	UT01-08	77	24	26	25	0.08	0.08	19	19	19	0	0
2008	UT65-08	78	23	25	24	0.08333333	0.08333333	18	18	18	0	0
2007	UT72-07	79	23	24	23.5	0.04255319	0.04255319	21	21	21	0	0
2007	UT02-07	80	23	23	23	0	0	18	18	18	0	0
2008	UT42-08	80	23	22	22.5	-0.0444444	0.04444444	19	17	18	-0.1111111	0.11111111
2008	UT90-08	81	27	28	27.5	0.03636364	0.03636364	20	20	20	0	0
2007	UT06-07	81	22	23	22.5	0.04444444	0.04444444	19	20	19.5	0.05128205	0.05128205
2006	UT71-06	81	23	25	24	0.08333333	0.08333333	17	18	17.5	0.05714286	0.05714286
2008	UT103-08	82	24	22	23	-0.0869565	0.08695652	21	21	21	0	0
2008	UT46-08	82	22	22	22	0	0	19	19	19	0	0
2004	UT65-04	82	22	23	22.5	0.04444444	0.04444444	19	20	19.5	0.05128205	0.05128205
2008	UT114-08	82	27	27	27	0	0	18	19	18.5	0.05405405	0.05405405
2006	UT82-06	84	26	25	25.5	-0.0392157	0.03921569	21	20	20.5	-0.0487805	0.04878049
2006	UT13-06	90	26	28	27	0.07407407	0.07407407	19	19	19	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	HUMHDDL	HUMHDDR	Mean	%DA	ABS	HUMEBRL	HUMEBRR	Mean	%DA	ABS
2006	UT65-06	31	50	50	50	0	0	62	62	62	0	0
2009	UT92-09	33	46	46	46	0	0	64	63	63.5	-0.015748	0.01574803
2001	UT32-01	33	48	48	48	0	0	65	64	64.5	-0.0155039	0.01550388
2007	UT50-07	38	48	49	48.5	0.02061856	0.02061856	68	67	67.5	-0.0148148	0.01481481
2008	UT100-08	39	49	49	49	0	0	62	62	62	0	0
2006	UT47-06	39	48	48	48	0	0	68	67	67.5	-0.0148148	0.01481481
2008	UT15-08	39	46	46	46	0	0					
2006	UT70-06	42	48	48	48	0	0	63	63	63	0	0
2008	UT104-08	43	52	52	52	0	0	62	64	63	0.03174603	0.03174603
2006	UT63-06	43	50	49	49.5	-0.020202	0.02020202	63	62	62.5	-0.016	0.016
2006	UT64-06	43	51	51	51	0	0	64	66	65	0.03076923	0.03076923
2007	UT89-07	43	49	49	49	0	0	63	66	64.5	0.04651163	0.04651163
2006	UT49-06	44	47	47	47	0	0	62	61	61.5	-0.0162602	0.01626016
2007	UT114-07	44	53	52	52.5	-0.0190476	0.01904762					
2007	UT53-07	44	49	48	48.5	-0.0206186	0.02061856	60	60	60	0	0
2007	UT53-07	44	47	46	46.5	-0.0215054	0.02150538	66	67	66.5	0.01503759	0.01503759
2005	UT81-05	45	49	48	48.5	-0.0206186	0.02061856					
2008	UT07-08	46	44	44	44	0	0	70	71	70.5	0.0141844	0.0141844
2004	UT73-04	46	48	49	48.5	0.02061856	0.02061856	64	63	63.5	-0.015748	0.01574803
2006	UT46-06	46	55	54	54.5	-0.0183486	0.01834862	68	69	68.5	0.01459854	0.01459854
2007	UT107-0	46	54	54	54	0	0	63	64	63.5	0.01574803	0.01574803
2007	UT11-07	47	52	52	52	0	0	64	65	64.5	0.01550388	0.01550388
2007	UT29-07	49	48	48	48	0	0	63	65	64	0.03125	0.03125
2006	UT08-06	50	49	49	49	0	0	64	65	64.5	0.01550388	0.01550388
2008	UT49-08	50	47	48	47.5	0.02105263	0.02105263	61	62	61.5	0.01626016	0.01626016
2007	UT83-07	50	46	46	46	0	0	66	67	66.5	0.01503759	0.01503759
2007	UT38-07	51	48	49	48.5	0.02061856	0.02061856	62	62	62	0	0
2008	UT04-08	51	49	49	49	0	0	65	67	66	0.03030303	0.03030303
2007	UT116-07	53	51	50	50.5	-0.019802	0.01980198	68	68	68	0	0
2005	UT78-05	53	54	54	54	0	0					
2008	UT05-08	53	51	51	51	0	0	62	61	61.5	-0.0162602	0.01626016
2007	UT12-07	53	52	53	52.5	0.01904762	0.01904762	69	69	69	0	0
2007	UT63-07	53	49	51	50	0.04	0.04	66	66	66	0	0
2007	UT99-07	54	48	48	48	0	0	60	59	59.5	-0.0168067	0.01680672
2007	UT21-07	54	49	51	50	0.04	0.04	61	63	62	0.03225806	0.03225806
2007	UT58-07	54	51	49	50	-0.04	0.04	65	65	65	0	0
2007	UT88-07	54	47	46	46.5	-0.0215054	0.02150538	65	63	64	-0.03125	0.03125
2007	UT110-07	54	50	50	50	0	0	63	63	63	0	0
2008	UT117-08	54	47	46	46.5	-0.0215054	0.02150538	65	64	64.5	-0.0155039	0.01550388
2006	UT80-06	55	49	47	48	-0.0416667	0.04166667	62	63	62.5	0.016	0.016
2005	UT72-05	55	49	49	49	0	0	65	65	65	0	0
2008	UT18-08	56	49	47	48	-0.0416667	0.04166667	63	62	62.5	-0.016	0.016
2006	UT34-06	56	48	48	48	0	0	62	63	62.5	0.016	0.016
2006	UT43-06	57	51	52	51.5	0.01941748	0.01941748	64	64	64	0	0
2006	UT72-06	57						72	72	72	0	0
2008	UT30-08	58	48	48	48	0	0	63	60	61.5	-0.0487805	0.04878049
2006	UT19-06	59	46	47	46.5	0.02150538	0.02150538	63	64	63.5	0.01574803	0.01574803
2007	UT46-07	59	51	50	50.5	-0.019802	0.01980198	65	66	65.5	0.01526718	0.01526718
2007	UT73-07	59	46	47	46.5	0.02150538	0.02150538	63	66	64.5	0.04651163	0.04651163
2002	UT07-02	59	46	46	46	0	0	64	64	64	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	HUMHDDL	HUMHDDR	Mean	%DA	ABS	HUMEBRL	HUMEBRR	Mean	%DA	ABS
2007	UT48-07	60	51	51	51	0	0	66	68	67	0.02985075	0.02985075
2006	UT97-06	61	47	47	47	0	0	62	64	63	0.03174603	0.03174603
2007	UT36-07	61	49	50	49.5	0.02020202	0.02020202					
2004	UT63-04	61						67	67	67	0	0
2007	UT64-07	61	49	53	51	0.07843137	0.07843137	68	69	68.5	0.01459854	0.01459854
2006	UT50-06	62	53	52	52.5	-0.0190476	0.01904762	66	66	66	0	0
2005	UT70-05	62						65	66	65.5	0.01526718	0.01526718
2006	UT86-06	62	51	51	51	0	0	73	73	73	0	0
2007	UT65-07	63	50	49	49.5	-0.020202	0.02020202	63	63	63	0	0
2006	UT31-06	63	50	51	50.5	0.01980198	0.01980198	68	67	67.5	-0.0148148	0.01481481
2005	UT73-05	63	48	49	48.5	0.02061856	0.02061856	64	64	64	0	0
2007	UT43-07	64	52	51	51.5	-0.0194175	0.01941748	62	63	62.5	0.016	0.016
2007	UT87-07	64	49	49	49	0	0	70	71	70.5	0.0141844	0.0141844
2008	UT14-08	64	46	48	47	0.04255319	0.04255319	63	65	64	0.03125	0.03125
2008	UT53-08	65	47	48	47.5	0.02105263	0.02105263	67	68	67.5	0.01481481	0.01481481
2007	UT103-0	66	48	47	47.5	-0.0210526	0.02105263	65	65	65	0	0
2008	UT118-08	67	49	48	48.5	-0.0206186	0.02061856	70	68	69	-0.0289855	0.02898551
2006	UT35-06	67	47	48	47.5	0.02105263	0.02105263	63	63	63	0	0
2007	UT22-07	67	49	48	48.5	-0.0206186	0.02061856	62	61	61.5	-0.0162602	0.01626016
2005	UT89-05	68	46	46	46	0	0	67	66	66.5	-0.0150376	0.01503759
2007	UT85-07	68	50	50	50	0	0	61	63	62	0.03225806	0.03225806
2007	UT104-0	68	48	50	49	0.04081633	0.04081633	64	66	65	0.03076923	0.03076923
2008	UT38-08	69	47	49	48	0.04166667	0.04166667	66	65	65.5	-0.0152672	0.01526718
2008	UT39-08	70	46	46	46	0	0	61	62	61.5	0.01626016	0.01626016
2007	UT42-07	70	53	53	53	0	0	67	67	67	0	0
2006	UT16-06	70	48	50	49	0.04081633	0.04081633	60	61	60.5	0.01652893	0.01652893
2008	UT09-08	70	48	50	49	0.04081633	0.04081633	65	65	65	0	0
2006	UT103-06	71	49	51	50	0.04	0.04	61	62	61.5	0.01626016	0.01626016
2007	UT84-07	71	49	50	49.5	0.02020202	0.02020202	67	64	65.5	-0.0458015	0.04580153
2006	UT01-06	71						64	62	63	-0.031746	0.03174603
2006	UT76-06	71						62	63	62.5	0.016	0.016
2006	UT07-06	71	49	51	50	0.04	0.04	59	61	60	0.03333333	0.03333333
2008	UT34-08	72	49	50	49.5	0.02020202	0.02020202	63	64	63.5	0.01574803	0.01574803
2003	UT64-03	72	49	50	49.5	0.02020202	0.02020202	69	70	69.5	0.01438849	0.01438849
2007	UT49-07	73	53	53	53	0	0	72	71	71.5	-0.013986	0.01398601
2007	UT47-07	74	53	53	53	0	0	68	70	69	0.02898551	0.02898551
2008	UT01-08	77	50	50	50	0	0	68	68	68	0	0
2008	UT65-08	78	54	54	54	0	0	69	68	68.5	-0.0145985	0.01459854
2007	UT72-07	79	51	51	51	0	0	64	65	64.5	0.01550388	0.01550388
2007	UT02-07	80	48	49	48.5	0.02061856	0.02061856	69	68	68.5	-0.0145985	0.01459854
2008	UT42-08	80						61	61	61	0	0
2008	UT90-08	81	48	49	48.5	0.02061856	0.02061856	61	61	61	0	0
2007	UT06-07	81	51	51	51	0	0	58	58	58	0	0
2006	UT71-06	81						63	66	64.5	0.04651163	0.04651163
2008	UT103-08	82	54	53	53.5	-0.0186916	0.01869159	66	66	66	0	0
2008	UT46-08	82	54	55	54.5	0.01834862	0.01834862	68	68	68	0	0
2004	UT65-04	82	48	48	48	0	0	69	69	69	0	0
2008	UT114-08	82	48	48	48	0	0	62	61	61.5	-0.0162602	0.01626016
2006	UT82-06	84	48	47	47.5	-0.0210526	0.02105263	66	66	66	0	0
2006	UT13-06	90	52	52	52	0	0	64	65	64.5	0.01550388	0.01550388

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	RADXLNL	RADXLNR	Mean	%DA	ABS	RADHDL	RADHDR	Mean	%DA	ABS
2006	UT65-06	31	231	232	231.5	0.00431965	0.00431965	24	24	24	0	0
2009	UT92-09	33	240	241	240.5	0.004158	0.004158	24	24	24	0	0
2001	UT32-01	33	271	275	273	0.01465201	0.01465201	23	23	23	0	0
2007	UT50-07	38	230	229	229.5	-0.0043573	0.0043573	23	24	23.5	0.04255319	0.04255319
2008	UT100-08	39	242	242	242	0	0	24	24	24	0	0
2006	UT47-06	39	262	262	262	0	0	22	22	22	0	0
2008	UT15-08	39	256	256	256	0	0	26	27	26.5	0.03773585	0.03773585
2006	UT70-06	42	275	274	274.5	-0.003643	0.00364299	23	23	23	0	0
2008	UT104-08	43	255	256	255.5	0.00391389	0.00391389	25	25	25	0	0
2006	UT63-06	43	230	234	232	0.01724138	0.01724138	24	24	24	0	0
2006	UT64-06	43	251	252	251.5	0.00397614	0.00397614	23	24	23.5	0.04255319	0.04255319
2007	UT89-07	43	255	260	257.5	0.01941748	0.01941748	26	26	26	0	0
2006	UT49-06	44	273	269	271	-0.0147601	0.01476015	22	22	22	0	0
2007	UT114-07	44	250	256	253	0.02371542	0.02371542	26	26	26	0	0
2007	UT53-07	44	262	260	261	-0.0076628	0.00766284	25	25	25	0	0
2007	UT53-07	44	274	275	274.5	0.00364299	0.00364299	23	23	23	0	0
2005	UT81-05	45	253	254	253.5	0.00394477	0.00394477	23	24	23.5	0.04255319	0.04255319
2008	UT07-08	46	223	225	224	0.00892857	0.00892857					
2004	UT73-04	46	258	258	258	0	0	25	25	25	0	0
2006	UT46-06	46	261	266	263.5	0.01897533	0.01897533	23	23	23	0	0
2007	UT107-0	46	272	272	272	0	0	23	23	23	0	0
2007	UT11-07	47	256	258	257	0.0077821	0.0077821	23	24	23.5	0.04255319	0.04255319
2007	UT29-07	49	277	277	277	0	0	25	26	25.5	0.03921569	0.03921569
2006	UT08-06	50	261	262	261.5	0.00382409	0.00382409	22	22	22	0	0
2008	UT49-08	50	268	265	266.5	-0.011257	0.01125704	24	25	24.5	0.04081633	0.04081633
2007	UT83-07	50	259	260	259.5	0.00385356	0.00385356					
2007	UT38-07	51	262	260	261	-0.0076628	0.00766284	25	25	25	0	0
2008	UT04-08	51	248	247	247.5	-0.0040404	0.0040404	22	24	23	0.08695652	0.08695652
2007	UT116-07	53	248	244	246	-0.0162602	0.01626016	25	25	25	0	0
2005	UT78-05	53	244	243	243.5	-0.0041068	0.00410678	26	26	26	0	0
2008	UT05-08	53						25	25	25	0	0
2007	UT12-07	53	260	256	258	-0.0155039	0.01550388	23	23	23	0	0
2007	UT63-07	53	263	266	264.5	0.01134216	0.01134216	22	23	22.5	0.04444444	0.04444444
2007	UT99-07	54	260	264	262	0.01526718	0.01526718	24	24	24	0	0
2007	UT21-07	54	270	267	268.5	-0.0111732	0.01117318	26	25	25.5	-0.0392157	0.03921569
2007	UT58-07	54	252	256	254	0.01574803	0.01574803	23	22	22.5	-0.0444444	0.04444444
2007	UT88-07	54	235	235	235	0	0	23	23	23	0	0
2007	UT110-07	54	266	271	268.5	0.01862197	0.01862197	26	26	26	0	0
2008	UT117-08	54	257	258	257.5	0.0038835	0.0038835					
2006	UT80-06	55	239	237	238	-0.0084034	0.00840336	25	25	25	0	0
2005	UT72-05	55	238	240	239	0.0083682	0.0083682	26	26	26	0	0
2008	UT18-08	56	232	235	233.5	0.01284797	0.01284797	24	23	23.5	-0.0425532	0.04255319
2006	UT34-06	56	244	247	245.5	0.01221996	0.01221996	24	24	24	0	0
2006	UT43-06	57	249	251	250	0.008	0.008	25	25	25	0	0
2006	UT72-06	57	249	250	249.5	0.00400802	0.00400802	24	25	24.5	0.04081633	0.04081633
2008	UT30-08	58	264	268	266	0.01503759	0.01503759	24	23	23.5	-0.0425532	0.04255319
2006	UT19-06	59	251	256	253.5	0.01972387	0.01972387	25	25	25	0	0
2007	UT46-07	59	259	264	261.5	0.01912046	0.01912046	23	23	23	0	0
2007	UT73-07	59	252	252	252	0	0	25	25	25	0	0
2002	UT07-02	59	272	278	275	0.02181818	0.02181818	23	23	23	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	RADXLNL	RADXLNR	Mean	%DA	ABS	RADHDL	RADHDR	Mean	%DA	ABS
2007	UT48-07	60	257	260	258.5	0.01160542	0.01160542	23	23	23	0	0
2006	UT97-06	61	268	270	269	0.00743494	0.00743494	24	24	24	0	0
2007	UT36-07	61	252	257	254.5	0.01964637	0.01964637	25	25	25	0	0
2004	UT63-04	61	253	257	255	0.01568627	0.01568627	24	24	24	0	0
2007	UT64-07	61	245	247	246	0.00813008	0.00813008	24	22	23	-0.0869565	0.08695652
2006	UT50-06	62	241	247	244	0.02459016	0.02459016	25	24	24.5	-0.0408163	0.04081633
2005	UT70-05	62	253	256	254.5	0.01178782	0.01178782	25	25	25	0	0
2006	UT86-06	62	261	265	263	0.01520913	0.01520913	25	25	25	0	0
2007	UT65-07	63	266	272	269	0.02230483	0.02230483	24	25	24.5	0.04081633	0.04081633
2006	UT31-06	63	266	269	267.5	0.01121495	0.01121495	26	26	26	0	0
2005	UT73-05	63	253	254	253.5	0.00394477	0.00394477	26	25	25.5	-0.0392157	0.03921569
2007	UT43-07	64	267	266	266.5	-0.0037523	0.00375235	25	24	24.5	-0.0408163	0.04081633
2007	UT87-07	64	255	256	255.5	0.00391389	0.00391389	26	26	26	0	0
2008	UT14-08	64	258	254	256	-0.015625	0.015625	24	24	24	0	0
2008	UT53-08	65	240	246	243	0.02469136	0.02469136	24	23	23.5	-0.0425532	0.04255319
2007	UT103-0	66	265	268	266.5	0.01125704	0.01125704	23	23	23	0	0
2008	UT118-08	67	261	265	263	0.01520913	0.01520913	25	26	25.5	0.03921569	0.03921569
2006	UT35-06	67	252	253	252.5	0.0039604	0.0039604	22	22	22	0	0
2007	UT22-07	67	253	250	251.5	-0.0119284	0.01192843	25	26	25.5	0.03921569	0.03921569
2005	UT89-05	68	263	263	263	0	0	26	27	26.5	0.03773585	0.03773585
2007	UT85-07	68	230	233	231.5	0.01295896	0.01295896	26	25	25.5	-0.0392157	0.03921569
2007	UT104-0	68	253	256	254.5	0.01178782	0.01178782					
2008	UT38-08	69	249	248	248.5	-0.0040241	0.00402414	25	25	25	0	0
2008	UT39-08	70	264	266	265	0.00754717	0.00754717	26	26	26	0	0
2007	UT42-07	70	262	263	262.5	0.00380952	0.00380952	26	26	26	0	0
2006	UT16-06	70						24	23	23.5	-0.0425532	0.04255319
2008	UT09-08	70	231	231	231	0	0	26	26	26	0	0
2006	UT103-06	71	261	263	262	0.00763359	0.00763359	24	25	24.5	0.04081633	0.04081633
2007	UT84-07	71	239	241	240	0.00833333	0.00833333					
2006	UT01-06	71	257	263	260	0.02307692	0.02307692	22	22	22	0	0
2006	UT76-06	71	275	271	273	-0.014652	0.01465201	24	23	23.5	-0.0425532	0.04255319
2006	UT07-06	71	250	252	251	0.00796813	0.00796813	24	25	24.5	0.04081633	0.04081633
2008	UT34-08	72	234	236	235	0.00851064	0.00851064	26	25	25.5	-0.0392157	0.03921569
2003	UT64-03	72	252	254	253	0.00790514	0.00790514	24	25	24.5	0.04081633	0.04081633
2007	UT49-07	73	266	268	267	0.00749064	0.00749064	23	23	23	0	0
2007	UT47-07	74	236	235	235.5	-0.0042463	0.00424628	29	30	29.5	0.03389831	0.03389831
2008	UT01-08	77	252	257	254.5	0.01964637	0.01964637	25	27	26	0.07692308	0.07692308
2008	UT65-08	78	253	254	253.5	0.00394477	0.00394477	25	25	25	0	0
2007	UT72-07	79	251	254	252.5	0.01188119	0.01188119	24	25	24.5	0.04081633	0.04081633
2007	UT02-07	80	230	230	230	0	0	23	24	23.5	0.04255319	0.04255319
2008	UT42-08	80	250	251	250.5	0.00399202	0.00399202	23	23	23	0	0
2008	UT90-08	81	252	250	251	-0.0079681	0.00796813	23	23	23	0	0
2007	UT06-07	81	275	275	275	0	0	26	26	26	0	0
2006	UT71-06	81	245	247	246	0.00813008	0.00813008	25	24	24.5	-0.0408163	0.04081633
2008	UT103-08	82	268	270	269	0.00743494	0.00743494	25	26	25.5	0.03921569	0.03921569
2008	UT46-08	82	267	266	266.5	-0.0037523	0.00375235	25	26	25.5	0.03921569	0.03921569
2004	UT65-04	82	243	249	246	0.02439024	0.02439024	23	24	23.5	0.04255319	0.04255319
2008	UT114-08	82	238	242	240	0.01666667	0.01666667	24	23	23.5	-0.0425532	0.04255319
2006	UT82-06	84	251	251	251	0	0	24	24	24	0	0
2006	UT13-06	90	229	231	230	0.00869565	0.00869565	24	24	24	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	RADAPDL	RADAPDR	Mean	%DA	ABS	FEMXLNL	FEMXLNR	Mean	%DA	ABS
2006	UT65-06	31	12	12	12	0	0	490	480	485	-0.0206186	0.02061856
2009	UT92-09	33	13	14	13.5	0.07407407	0.07407407	452	452	452	0	0
2001	UT32-01	33	13	13	13	0	0	463	466	464.5	0.00645856	0.00645856
2007	UT50-07	38	12	12	12	0	0	441	441	441	0	0
2008	UT100-08	39	13	13	13	0	0	512	510	511	-0.0039139	0.00391389
2006	UT47-06	39	13	13	13	0	0	491	482	486.5	-0.0184995	0.01849949
2008	UT15-08	39	12	12	12	0	0	491	491	491	0	0
2006	UT70-06	42	13	12	12.5	-0.08	0.08	469	476	472.5	0.01481481	0.01481481
2008	UT104-08	43	13	13	13	0	0	459	460	459.5	0.00217628	0.00217628
2006	UT63-06	43	13	13	13	0	0	414	415	414.5	0.00241255	0.00241255
2006	UT64-06	43	12	11	11.5	-0.0869565	0.08695652	497	493	495	-0.0080808	0.00808081
2007	UT89-07	43	12	12	12	0	0	469	464	466.5	-0.0107181	0.01071811
2006	UT49-06	44	13	13	13	0	0	500	497	498.5	-0.0060181	0.00601805
2007	UT114-07	44	11	11	11	0	0	472	473	472.5	0.0021164	0.0021164
2007	UT53-07	44	13	14	13.5	0.07407407	0.07407407	487	493	490	0.0122449	0.0122449
2007	UT53-07	44	13	14	13.5	0.07407407	0.07407407	427	426	426.5	-0.0023447	0.00234467
2005	UT81-05	45	12	12	12	0	0	470	464	467	-0.012848	0.01284797
2008	UT07-08	46	13	13	13	0	0	484	481	482.5	-0.0062176	0.00621762
2004	UT73-04	46	12	12	12	0	0	447	453	450	0.01333333	0.01333333
2006	UT46-06	46	14	14	14	0	0	472	473	472.5	0.0021164	0.0021164
2007	UT107-0	46	12	12	12	0	0	430	420	425	-0.0235294	0.02352941
2007	UT11-07	47	12	12	12	0	0	518	514	516	-0.0077519	0.00775194
2007	UT29-07	49	13	13	13	0	0	485	490	487.5	0.01025641	0.01025641
2006	UT08-06	50	13	12	12.5	-0.08	0.08	508	502	505	-0.0118812	0.01188119
2008	UT49-08	50	14	14	14	0	0	499	498	498.5	-0.002006	0.00200602
2007	UT83-07	50	12	13	12.5	0.08	0.08	455	456	455.5	0.00219539	0.00219539
2007	UT38-07	51	13	13	13	0	0	496	493	494.5	-0.0060667	0.00606673
2008	UT04-08	51	13	14	13.5	0.07407407	0.07407407	465	470	467.5	0.01069519	0.01069519
2007	UT116-07	53	13	13	13	0	0	457	460	458.5	0.00654308	0.00654308
2005	UT78-05	53	13	13	13	0	0	437	438	437.5	0.00228571	0.00228571
2008	UT05-08	53	15	14	14.5	-0.0689655	0.06896552	461	463	462	0.004329	0.004329
2007	UT12-07	53	13	14	13.5	0.07407407	0.07407407	475	481	478	0.0125523	0.0125523
2007	UT63-07	53	15	14	14.5	-0.0689655	0.06896552	431	429	430	-0.0046512	0.00465116
2007	UT99-07	54	16	16	16	0	0	486	483	484.5	-0.006192	0.00619195
2007	UT21-07	54	11	12	11.5	0.08695652	0.08695652	458	455	456.5	-0.0065717	0.00657174
2007	UT58-07	54	13	13	13	0	0	487	489	488	0.00409836	0.00409836
2007	UT88-07	54						498	486	492	-0.0243902	0.02439024
2007	UT110-07	54	14	14	14	0	0	480	480	480	0	0
2008	UT117-08	54	12	12	12	0	0	497	494	495.5	-0.0060545	0.00605449
2006	UT80-06	55	12	12	12	0	0	466	476	471	0.02123142	0.02123142
2005	UT72-05	55	13	13	13	0	0	456	459	457.5	0.00655738	0.00655738
2008	UT18-08	56	13	13	13	0	0	474	471	472.5	-0.0063492	0.00634921
2006	UT34-06	56	13	13	13	0	0	484	481	482.5	-0.0062176	0.00621762
2006	UT43-06	57	11	12	11.5	0.08695652	0.08695652	494	503	498.5	0.01805416	0.01805416
2006	UT72-06	57	13	12	12.5	-0.08	0.08	493	500	496.5	0.01409869	0.01409869
2008	UT30-08	58	14	13	13.5	-0.0740741	0.07407407	470	477	473.5	0.01478353	0.01478353
2006	UT19-06	59	12	13	12.5	0.08	0.08	457	456	456.5	-0.0021906	0.00219058
2007	UT46-07	59	14	14	14	0	0	430	426	428	-0.0093458	0.00934579
2007	UT73-07	59	13	14	13.5	0.07407407	0.07407407	438	433	435.5	-0.0114811	0.01148106
2002	UT07-02	59	13	13	13	0	0	510	511	510.5	0.00195886	0.00195886

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	RADAPDL	RADAPDR	Mean	%DA	ABS	FEMXLNL	FEMXLNR	Mean	%DA	ABS
2007	UT48-07	60	13	13	13	0	0	449	445	447	-0.0089485	0.00894855
2006	UT97-06	61	13	13	13	0	0	476	478	477	0.00419287	0.00419287
2007	UT36-07	61	12	12	12	0	0	420	423	421.5	0.00711744	0.00711744
2004	UT63-04	61	13	12	12.5	-0.08	0.08	473	471	472	-0.0042373	0.00423729
2007	UT64-07	61	13	13	13	0	0	461	460	460.5	-0.0021716	0.00217155
2006	UT50-06	62	13	13	13	0	0	477	481	479	0.00835073	0.00835073
2005	UT70-05	62	14	14	14	0	0	473	468	470.5	-0.010627	0.01062699
2006	UT86-06	62	12	12	12	0	0	464	466	465	0.00430108	0.00430108
2007	UT65-07	63	12	13	12.5	0.08	0.08	450	449	449.5	-0.0022247	0.00222469
2006	UT31-06	63	13	14	13.5	0.07407407	0.07407407	471	474	472.5	0.00634921	0.00634921
2005	UT73-05	63	13	14	13.5	0.07407407	0.07407407	486	483	484.5	-0.006192	0.00619195
2007	UT43-07	64	14	14	14	0	0	462	461	461.5	-0.0021668	0.00216685
2007	UT87-07	64	14	14	14	0	0	455	457	456	0.00438596	0.00438596
2008	UT14-08	64	13	13	13	0	0	452	455	453.5	0.00661521	0.00661521
2008	UT53-08	65	12	12	12	0	0	487	488	487.5	0.00205128	0.00205128
2007	UT103-0	66	13	14	13.5	0.07407407	0.07407407	463	460	461.5	-0.0065005	0.00650054
2008	UT118-08	67	13	13	13	0	0	454	456	455	0.0043956	0.0043956
2006	UT35-06	67	12	12	12	0	0	526	518	522	-0.0153257	0.01532567
2007	UT22-07	67	13	13	13	0	0	437	433	435	-0.0091954	0.0091954
2005	UT89-05	68	13	13	13	0	0	476	487	481.5	0.02284528	0.02284528
2007	UT85-07	68	14	15	14.5	0.06896552	0.06896552	425	426	425.5	0.00235018	0.00235018
2007	UT104-0	68	14	14	14	0	0	483	481	482	-0.0041494	0.00414938
2008	UT38-08	69	14	14	14	0	0	441	438	439.5	-0.0068259	0.00682594
2008	UT39-08	70	15	15	15	0	0	488	484	486	-0.0082305	0.00823045
2007	UT42-07	70	13	13	13	0	0	482	483	482.5	0.00207254	0.00207254
2006	UT16-06	70	12	12	12	0	0	433	436	434.5	0.00690449	0.00690449
2008	UT09-08	70	14	14	14	0	0	496	495	495.5	-0.0020182	0.00201816
2006	UT103-06	71	16	15	15.5	-0.0645161	0.06451613	481	484	482.5	0.00621762	0.00621762
2007	UT84-07	71	13	13	13	0	0	473	470	471.5	-0.0063627	0.00636267
2006	UT01-06	71	13	13	13	0	0	464	460	462	-0.008658	0.00865801
2006	UT76-06	71	13	13	13	0	0	434	435	434.5	0.0023015	0.0023015
2006	UT07-06	71	12	12	12	0	0	520	519	519.5	-0.0019249	0.00192493
2008	UT34-08	72	12	12	12	0	0					
2003	UT64-03	72	13	13	13	0	0	462	462	462	0	0
2007	UT49-07	73	14	15	14.5	0.06896552	0.06896552	484	487	485.5	0.0061792	0.0061792
2007	UT47-07	74	13	14	13.5	0.07407407	0.07407407	460	457	458.5	-0.0065431	0.00654308
2008	UT01-08	77	12	13	12.5	0.08	0.08	437	438	437.5	0.00228571	0.00228571
2008	UT65-08	78	18	17	17.5	-0.0571429	0.05714286	507	507	507	0	0
2007	UT72-07	79	12	13	12.5	0.08	0.08	443	446	444.5	0.00674916	0.00674916
2007	UT02-07	80	14	14	14	0	0	463	465	464	0.00431034	0.00431034
2008	UT42-08	80	14	14	14	0	0	493	494	493.5	0.00202634	0.00202634
2008	UT90-08	81	13	13	13	0	0	483	478	480.5	-0.0104058	0.01040583
2007	UT06-07	81	15	16	15.5	0.06451613	0.06451613	468	464	466	-0.0085837	0.00858369
2006	UT71-06	81	13	13	13	0	0	475	471	473	-0.0084567	0.00845666
2008	UT103-08	82	13	14	13.5	0.07407407	0.07407407	492	490	491	-0.0040733	0.00407332
2008	UT46-08	82	14	14	14	0	0					
2004	UT65-04	82	12	13	12.5	0.08	0.08	449	447	448	-0.0044643	0.00446429
2008	UT114-08	82	14	14	14	0	0	503	502	502.5	-0.00199	0.00199005
2006	UT82-06	84	13	13	13	0	0	461	465	463	0.00863931	0.00863931
2006	UT13-06	90	14	14	14	0	0	499	494	496.5	-0.0100705	0.01007049

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	FEMBLNL	FEMBLNR	Mean	%DA	ABS	FEMMAPL	FEMMAPR	Mean	%DA	ABS
2006	UT65-06	31	489	495	492	0.01219512	0.01219512	36	33	34.5	-0.0869565	0.08695652
2009	UT92-09	33	444	449	446.5	0.01119821	0.01119821	29	29	29	0	0
2001	UT32-01	33	488	489	488.5	0.00204708	0.00204708	31	31	31	0	0
2007	UT50-07	38	427	418	422.5	-0.0213018	0.02130178	31	33	32	0.0625	0.0625
2008	UT100-08	39	459	462	460.5	0.00651466	0.00651466	33	34	33.5	0.02985075	0.02985075
2006	UT47-06	39	454	453	453.5	-0.0022051	0.00220507	32	31	31.5	-0.031746	0.03174603
2008	UT15-08	39	484	476	480	-0.0166667	0.01666667	30	30	30	0	0
2006	UT70-06	42	507	501	504	-0.0119048	0.01190476	32	33	32.5	0.03076923	0.03076923
2008	UT104-08	43	488	475	481.5	-0.026999	0.02699896	34	34	34	0	0
2006	UT63-06	43	480	476	478	-0.0083682	0.0083682	32	33	32.5	0.03076923	0.03076923
2006	UT64-06	43	515	511	513	-0.0077973	0.00779727	34	33	33.5	-0.0298507	0.02985075
2007	UT89-07	43	430	427	428.5	-0.0070012	0.00700117	32	32	32	0	0
2006	UT49-06	44	412	412	412	0	0	33	33	33	0	0
2007	UT114-07	44	433	436	434.5	0.00690449	0.00690449	34	36	35	0.05714286	0.05714286
2007	UT53-07	44	450	449	449.5	-0.0022247	0.00222469	32	31	31.5	-0.031746	0.03174603
2007	UT53-07	44	480	476	478	-0.0083682	0.0083682	29	28	28.5	-0.0350877	0.03508772
2005	UT81-05	45	473	473	473	0	0	29	30	29.5	0.03389831	0.03389831
2008	UT07-08	46	465	461	463	-0.0086393	0.00863931	32	30	31	-0.0645161	0.06451613
2004	UT73-04	46	465	472	468.5	0.0149413	0.0149413	32	32	32	0	0
2006	UT46-06	46	456	456	456	0	0	31	31	31	0	0
2007	UT107-0	46	455	452	453.5	-0.0066152	0.00661521	35	36	35.5	0.02816901	0.02816901
2007	UT11-07	47	438	437	437.5	-0.0022857	0.00228571	31	31	31	0	0
2007	UT29-07	49	486	488	487	0.00410678	0.00410678	29	29	29	0	0
2006	UT08-06	50	425	423	424	-0.004717	0.00471698	31	32	31.5	0.03174603	0.03174603
2008	UT49-08	50	493	490	491.5	-0.0061038	0.00610376	32	32	32	0	0
2007	UT83-07	50	451	454	452.5	0.00662983	0.00662983	32	32	32	0	0
2007	UT38-07	51	470	470	470	0	0	27	26	26.5	-0.0377358	0.03773585
2008	UT04-08	51	456	457	456.5	0.00219058	0.00219058	31	30	30.5	-0.0327869	0.03278689
2007	UT116-07	53	483	488	485.5	0.01029866	0.01029866	26	26	26	0	0
2005	UT78-05	53	465	475	470	0.0212766	0.0212766	30	30	30	0	0
2008	UT05-08	53	482	478	480	-0.0083333	0.00833333	29	30	29.5	0.03389831	0.03389831
2007	UT12-07	53	483	489	486	0.01234568	0.01234568	30	30	30	0	0
2007	UT63-07	53	453	454	453.5	0.00220507	0.00220507	30	31	30.5	0.03278689	0.03278689
2007	UT99-07	54	429	424	426.5	-0.0117233	0.01172333	29	30	29.5	0.03389831	0.03389831
2007	UT21-07	54	464	459	461.5	-0.0108342	0.01083424	30	30	30	0	0
2007	UT58-07	54	497	496	496.5	-0.0020141	0.0020141	34	33	33.5	-0.0298507	0.02985075
2007	UT88-07	54	493	488	490.5	-0.0101937	0.01019368	32	31	31.5	-0.031746	0.03174603
2007	UT110-07	54	504	502	503	-0.0039761	0.00397614	27	26	26.5	-0.0377358	0.03773585
2008	UT117-08	54	476	475	475.5	-0.002103	0.00210305	29	28	28.5	-0.0350877	0.03508772
2006	UT80-06	55	490	498	494	0.01619433	0.01619433	35	34	34.5	-0.0289855	0.02898551
2005	UT72-05	55	496	496	496	0	0	27	28	27.5	0.03636364	0.03636364
2008	UT18-08	56	470	471	470.5	0.0021254	0.0021254	36	37	36.5	0.02739726	0.02739726
2006	UT34-06	56	502	504	503	0.00397614	0.00397614	31	31	31	0	0
2006	UT43-06	57	453	454	453.5	0.00220507	0.00220507	29	28	28.5	-0.0350877	0.03508772
2006	UT72-06	57	461	465	463	0.00863931	0.00863931	31	30	30.5	-0.0327869	0.03278689
2008	UT30-08	58	467	474	470.5	0.01487779	0.01487779	28	29	28.5	0.03508772	0.03508772
2006	UT19-06	59	490	487	488.5	-0.0061412	0.00614125	26	25	25.5	-0.0392157	0.03921569
2007	UT46-07	59	473	471	472	-0.0042373	0.00423729	30	30	30	0	0
2007	UT73-07	59	436	431	433.5	-0.011534	0.01153403	27	27	27	0	0
2002	UT07-02	59	493	482	487.5	-0.0225641	0.0225641	28	28	28	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	FEMBLNL	FEMBLNR	Mean	%DA	ABS	FEMMAPL	FEMMAPR	Mean	%DA	ABS
2007	UT48-07	60	481	478	479.5	-0.0062565	0.00625652	31	32	31.5	0.03174603	0.03174603
2006	UT97-06	61	462	458	460	-0.0086957	0.00869565	34	34	34	0	0
2007	UT36-07	61	462	459	460.5	-0.0065147	0.00651466	35	35	35	0	0
2004	UT63-04	61	473	482	477.5	0.01884817	0.01884817	31	31	31	0	0
2007	UT64-07	61	498	493	495.5	-0.0100908	0.01009082	26	28	27	0.07407407	0.07407407
2006	UT50-06	62	481	482	481.5	0.00207684	0.00207684	30	31	30.5	0.03278689	0.03278689
2005	UT70-05	62	449	446	447.5	-0.0067039	0.00670391	31	31	31	0	0
2006	UT86-06	62						33	34	33.5	0.02985075	0.02985075
2007	UT65-07	63	445	442	443.5	-0.0067644	0.00676437	34	34	34	0	0
2006	UT31-06	63	472	476	474	0.00843882	0.00843882	32	32	32	0	0
2005	UT73-05	63	517	514	515.5	-0.0058196	0.00581959	30	30	30	0	0
2007	UT43-07	64	470	467	468.5	-0.0064034	0.00640342	33	33	33	0	0
2007	UT87-07	64	432	429	430.5	-0.0069686	0.00696864	32	31	31.5	-0.031746	0.03174603
2008	UT14-08	64	499	498	498.5	-0.002006	0.00200602	29	29	29	0	0
2008	UT53-08	65	483	480	481.5	-0.0062305	0.00623053	29	31	30	0.06666667	0.06666667
2007	UT103-0	66	431	435	433	0.00923788	0.00923788	33	34	33.5	0.02985075	0.02985075
2008	UT118-08	67	448	450	449	0.00445434	0.00445434	31	30	30.5	-0.0327869	0.03278689
2006	UT35-06	67	447	445	446	-0.0044843	0.0044843	34	32	33	-0.0606061	0.06060606
2007	UT22-07	67	488	487	487.5	-0.0020513	0.00205128	30	30	30	0	0
2005	UT89-05	68	436	435	435.5	-0.0022962	0.00229621	31	30	30.5	-0.0327869	0.03278689
2007	UT85-07	68	463	465	464	0.00431034	0.00431034	29	28	28.5	-0.0350877	0.03508772
2007	UT104-0	68	419	421	420	0.0047619	0.0047619	31	30	30.5	-0.0327869	0.03278689
2008	UT38-08	69	458	457	457.5	-0.0021858	0.00218579	30	33	31.5	0.0952381	0.0952381
2008	UT39-08	70	478	481	479.5	0.00625652	0.00625652	28	30	29	0.06896552	0.06896552
2007	UT42-07	70	478	475	476.5	-0.0062959	0.00629591	32	33	32.5	0.03076923	0.03076923
2006	UT16-06	70	506	504	505	-0.0039604	0.0039604	32	31	31.5	-0.031746	0.03174603
2008	UT09-08	70	438	436	437	-0.0045767	0.00457666	33	32	32.5	-0.0307692	0.03076923
2006	UT103-06	71	472	470	471	-0.0042463	0.00424628	29	29	29	0	0
2007	UT84-07	71	459	462	460.5	0.00651466	0.00651466	30	30	30	0	0
2006	UT01-06	71	457	452	454.5	-0.0110011	0.0110011	30	30	30	0	0
2006	UT76-06	71	480	479	479.5	-0.0020855	0.00208551	29	30	29.5	0.03389831	0.03389831
2006	UT07-06	71	520	513	516.5	-0.0135528	0.01355276	32	33	32.5	0.03076923	0.03076923
2008	UT34-08	72	494	492	493	-0.0040568	0.0040568	32	31	31.5	-0.031746	0.03174603
2003	UT64-03	72	481	482	481.5	0.00207684	0.00207684	36	37	36.5	0.02739726	0.02739726
2007	UT49-07	73	457	458	457.5	0.00218579	0.00218579	33	32	32.5	-0.0307692	0.03076923
2007	UT47-07	74	433	434	433.5	0.00230681	0.00230681	36	36	36	0	0
2008	UT01-08	77	469	461	465	-0.0172043	0.0172043	31	30	30.5	-0.0327869	0.03278689
2008	UT65-08	78	451	452	451.5	0.00221484	0.00221484	30	27	28.5	-0.1052632	0.10526316
2007	UT72-07	79	484	485	484.5	0.00206398	0.00206398	32	32	32	0	0
2007	UT02-07	80						32	32	32	0	0
2008	UT42-08	80	471	472	471.5	0.00212089	0.00212089	30	30	30	0	0
2008	UT90-08	81	440	441	440.5	0.00227015	0.00227015	36	35	35.5	-0.028169	0.02816901
2007	UT06-07	81	469	470	469.5	0.00212993	0.00212993	35	34	34.5	-0.0289855	0.02898551
2006	UT71-06	81	423	425	424	0.00471698	0.00471698	28	27	27.5	-0.0363636	0.03636364
2008	UT103-08	82	447	450	448.5	0.00668896	0.00668896	31	30	30.5	-0.0327869	0.03278689
2008	UT46-08	82	460	461	460.5	0.00217155	0.00217155	31	31	31	0	0
2004	UT65-04	82	455	452	453.5	-0.0066152	0.00661521	30	29	29.5	-0.0338983	0.03389831
2008	UT114-08	82	491	492	491.5	0.00203459	0.00203459	35	35	35	0	0
2006	UT82-06	84	460	456	458	-0.0087336	0.00873362	29	29	29	0	0
2006	UT13-06	90	468	468	468	0	0	25	26	25.5	0.03921569	0.03921569

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	FEMMTVL	FEMMTVR	Mean	%DA	ABS	FEMHDDL	FEMHDDR	Mean	%DA	ABS
2006	UT65-06	31	29	29	29	0	0	49	48	48.5	-0.0206186	0.02061856
2009	UT92-09	33	26	25	25.5	-0.0392157	0.03921569	49	50	49.5	0.02020202	0.02020202
2001	UT32-01	33	27	30	28.5	0.10526316	0.10526316	52	53	52.5	0.01904762	0.01904762
2007	UT50-07	38	31	31	31	0	0	46	46	46	0	0
2008	UT100-08	39	27	28	27.5	0.03636364	0.03636364	47	46	46.5	-0.0215054	0.02150538
2006	UT47-06	39	26	26	26	0	0	48	48	48	0	0
2008	UT15-08	39	26	25	25.5	-0.0392157	0.03921569	47	47	47	0	0
2006	UT70-06	42	29	29	29	0	0	46	46	46	0	0
2008	UT104-08	43	27	27	27	0	0					
2006	UT63-06	43	32	30	31	-0.0645161	0.06451613	48	47	47.5	-0.0210526	0.02105263
2006	UT64-06	43	30	29	29.5	-0.0338983	0.03389831	51	51	51	0	0
2007	UT89-07	43	27	27	27	0	0	48	48	48	0	0
2006	UT49-06	44	28	26	27	-0.0740741	0.07407407	46	45	45.5	-0.021978	0.02197802
2007	UT114-07	44	27	27	27	0	0	50	50	50	0	0
2007	UT53-07	44	30	29	29.5	-0.0338983	0.03389831	46	48	47	0.04255319	0.04255319
2007	UT53-07	44	31	30	30.5	-0.0327869	0.03278689	46	45	45.5	-0.021978	0.02197802
2005	UT81-05	45	26	26	26	0	0	49	49	49	0	0
2008	UT07-08	46	27	28	27.5	0.03636364	0.03636364	45	46	45.5	0.02197802	0.02197802
2004	UT73-04	46	32	32	32	0	0	51	50	50.5	-0.019802	0.01980198
2006	UT46-06	46	25	27	26	0.07692308	0.07692308	51	51	51	0	0
2007	UT107-0	46	27	27	27	0	0	47	47	47	0	0
2007	UT11-07	47	27	26	26.5	-0.0377358	0.03773585	44	44	44	0	0
2007	UT29-07	49	28	28	28	0	0	47	48	47.5	0.02105263	0.02105263
2006	UT08-06	50	33	33	33	0	0	48	48	48	0	0
2008	UT49-08	50	28	26	27	-0.0740741	0.07407407	51	50	50.5	-0.019802	0.01980198
2007	UT83-07	50	27	27	27	0	0	45	44	44.5	-0.0224719	0.02247191
2007	UT38-07	51	29	28	28.5	-0.0350877	0.03508772	53	53	53	0	0
2008	UT04-08	51	26	27	26.5	0.03773585	0.03773585	46	45	45.5	-0.021978	0.02197802
2007	UT116-07	53	26	26	26	0	0	48	49	48.5	0.02061856	0.02061856
2005	UT78-05	53	30	28	29	-0.0689655	0.06896552	51	51	51	0	0
2008	UT05-08	53	28	27	27.5	-0.0363636	0.03636364	46	46	46	0	0
2007	UT12-07	53	30	31	30.5	0.03278689	0.03278689	49	50	49.5	0.02020202	0.02020202
2007	UT63-07	53	25	25	25	0	0	45	45	45	0	0
2007	UT99-07	54	28	28	28	0	0	47	47	47	0	0
2007	UT21-07	54	27	27	27	0	0	50	50	50	0	0
2007	UT58-07	54	29	29	29	0	0	44	45	44.5	0.02247191	0.02247191
2007	UT88-07	54	28	28	28	0	0	48	49	48.5	0.02061856	0.02061856
2007	UT110-07	54	26	25	25.5	-0.0392157	0.03921569	46	46	46	0	0
2008	UT117-08	54	25	27	26	0.07692308	0.07692308	47	47	47	0	0
2006	UT80-06	55	31	30	30.5	-0.0327869	0.03278689	48	49	48.5	0.02061856	0.02061856
2005	UT72-05	55	29	30	29.5	0.03389831	0.03389831	46	46	46	0	0
2008	UT18-08	56	26	27	26.5	0.03773585	0.03773585	47	47	47	0	0
2006	UT34-06	56	31	30	30.5	-0.0327869	0.03278689	51	53	52	0.03846154	0.03846154
2006	UT43-06	57	29	29	29	0	0	46	45	45.5	-0.021978	0.02197802
2006	UT72-06	57	27	28	27.5	0.03636364	0.03636364					
2008	UT30-08	58	30	28	29	-0.0689655	0.06896552	46	46	46	0	0
2006	UT19-06	59	28	28	28	0	0	50	50	50	0	0
2007	UT46-07	59	25	25	25	0	0	47	46	46.5	-0.0215054	0.02150538
2007	UT73-07	59	26	25	25.5	-0.0392157	0.03921569	46	46	46	0	0
2002	UT07-02	59	26	26	26	0	0	46	45	45.5	-0.021978	0.02197802

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	FEMMTVL	FEMMTVR	Mean	%DA	ABS	FEMHDDL	FEMHDDR	Mean	%DA	ABS
2007	UT48-07	60	30	29	29.5	-0.0338983	0.03389831	50	51	50.5	0.01980198	0.01980198
2006	UT97-06	61	29	28	28.5	-0.0350877	0.03508772	51	52	51.5	0.01941748	0.01941748
2007	UT36-07	61	29	30	29.5	0.03389831	0.03389831	50	51	50.5	0.01980198	0.01980198
2004	UT63-04	61	29	28	28.5	-0.0350877	0.03508772	47	47	47	0	0
2007	UT64-07	61	29	30	29.5	0.03389831	0.03389831	53	53	53	0	0
2006	UT50-06	62	31	29	30	-0.0666667	0.06666667	48	48	48	0	0
2005	UT70-05	62	28	27	27.5	-0.0363636	0.03636364	47	48	47.5	0.02105263	0.02105263
2006	UT86-06	62	28	28	28	0	0	51	52	51.5	0.01941748	0.01941748
2007	UT65-07	63	28	28	28	0	0	52	52	52	0	0
2006	UT31-06	63	33	33	33	0	0	49	50	49.5	0.02020202	0.02020202
2005	UT73-05	63	28	28	28	0	0	49	48	48.5	-0.0206186	0.02061856
2007	UT43-07	64	29	29	29	0	0	45	44	44.5	-0.0224719	0.02247191
2007	UT87-07	64	29	30	29.5	0.03389831	0.03389831	50	51	50.5	0.01980198	0.01980198
2008	UT14-08	64	30	31	30.5	0.03278689	0.03278689	50	49	49.5	-0.020202	0.02020202
2008	UT53-08	65	28	27	27.5	-0.0363636	0.03636364	48	49	48.5	0.02061856	0.02061856
2007	UT103-0	66	28	28	28	0	0	51	51	51	0	0
2008	UT118-08	67	31	31	31	0	0	55	56	55.5	0.01801802	0.01801802
2006	UT35-06	67	28	28	28	0	0	50	50	50	0	0
2007	UT22-07	67	27	27	27	0	0	51	51	51	0	0
2005	UT89-05	68	28	28	28	0	0	47	48	47.5	0.02105263	0.02105263
2007	UT85-07	68	30	27	28.5	-0.1052632	0.10526316	45	45	45	0	0
2007	UT104-0	68	29	27	28	-0.0714286	0.07142857	48	49	48.5	0.02061856	0.02061856
2008	UT38-08	69	30	27	28.5	-0.1052632	0.10526316	48	49	48.5	0.02061856	0.02061856
2008	UT39-08	70	29	29	29	0	0	48	49	48.5	0.02061856	0.02061856
2007	UT42-07	70	29	30	29.5	0.03389831	0.03389831	47	47	47	0	0
2006	UT16-06	70	30	29	29.5	-0.0338983	0.03389831	49	50	49.5	0.02020202	0.02020202
2008	UT09-08	70	28	27	27.5	-0.0363636	0.03636364	50	50	50	0	0
2006	UT103-06	71	29	31	30	0.06666667	0.06666667	47	48	47.5	0.02105263	0.02105263
2007	UT84-07	71	34	30	32	-0.125	0.125	47	46	46.5	-0.0215054	0.02150538
2006	UT01-06	71	33	29	31	-0.1290323	0.12903226	48	48	48	0	0
2006	UT76-06	71	27	26	26.5	-0.0377358	0.03773585	49	50	49.5	0.02020202	0.02020202
2006	UT07-06	71	28	28	28	0	0	45	47	46	0.04347826	0.04347826
2008	UT34-08	72	26	26	26	0	0	46	45	45.5	-0.021978	0.02197802
2003	UT64-03	72	27	27	27	0	0	52	52	52	0	0
2007	UT49-07	73	26	26	26	0	0	52	51	51.5	-0.0194175	0.01941748
2007	UT47-07	74	32	29	30.5	-0.0983607	0.09836066	49	50	49.5	0.02020202	0.02020202
2008	UT01-08	77	27	28	27.5	0.03636364	0.03636364	46	47	46.5	0.02150538	0.02150538
2008	UT65-08	78	29	28	28.5	-0.0350877	0.03508772	51	52	51.5	0.01941748	0.01941748
2007	UT72-07	79	34	33	33.5	-0.0298507	0.02985075	49	49	49	0	0
2007	UT02-07	80	34	32	33	-0.0606061	0.06060606	48	49	48.5	0.02061856	0.02061856
2008	UT42-08	80	28	29	28.5	0.03508772	0.03508772	49	49	49	0	0
2008	UT90-08	81	29	30	29.5	0.03389831	0.03389831	45	45	45	0	0
2007	UT06-07	81	26	26	26	0	0	49	51	50	0.04	0.04
2006	UT71-06	81	27	27	27	0	0	52	51	51.5	-0.0194175	0.01941748
2008	UT103-08	82	29	28	28.5	-0.0350877	0.03508772	48	49	48.5	0.02061856	0.02061856
2008	UT46-08	82	26	28	27	0.07407407	0.07407407	50	51	50.5	0.01980198	0.01980198
2004	UT65-04	82	29	28	28.5	-0.0350877	0.03508772	52	52	52	0	0
2008	UT114-08	82	28	28	28	0	0	52	54	53	0.03773585	0.03773585
2006	UT82-06	84	27	27	27	0	0	47	47	47	0	0
2006	UT13-06	90	26	28	27	0.07407407	0.07407407	52	53	52.5	0.01904762	0.01904762

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	FEMEBRL	FEMEBRR	Mean	%DA	ABS	FEMCIRL	FEMCIRR	Mean	%DA	ABS
2006	UT65-06	31	86	85	85.5	-0.0116959	0.01169591	83	84	83.5	0.01197605	0.01197605
2009	UT92-09	33	82	82	82	0	0	89	87	88	-0.0227273	0.02272727
2001	UT32-01	33	88	88	88	0	0	98	99	98.5	0.01015228	0.01015228
2007	UT50-07	38	84	84	84	0	0	96	95	95.5	-0.0104712	0.0104712
2008	UT100-08	39	86	84	85	-0.0235294	0.02352941	89	91	90	0.02222222	0.02222222
2006	UT47-06	39	89	88	88.5	-0.0112994	0.01129944	101	102	101.5	0.00985222	0.00985222
2008	UT15-08	39	82	83	82.5	0.01212121	0.01212121	95	95	95	0	0
2006	UT70-06	42						85	86	85.5	0.01169591	0.01169591
2008	UT104-08	43	86	86	86	0	0	83	87	85	0.04705882	0.04705882
2006	UT63-06	43	83	82	82.5	-0.0121212	0.01212121	103	101	102	-0.0196078	0.01960784
2006	UT64-06	43	84	84	84	0	0	89	89	89	0	0
2007	UT89-07	43	91	91	91	0	0	89	89	89	0	0
2006	UT49-06	44	82	82	82	0	0	99	99	99	0	0
2007	UT114-07	44	81	82	81.5	0.01226994	0.01226994	90	93	91.5	0.03278689	0.03278689
2007	UT53-07	44	88	88	88	0	0	86	88	87	0.02298851	0.02298851
2007	UT53-07	44	88	88	88	0	0	99	100	99.5	0.01005025	0.01005025
2005	UT81-05	45	84	85	84.5	0.01183432	0.01183432	89	88	88.5	-0.0112994	0.01129944
2008	UT07-08	46	87	87	87	0	0	101	103	102	0.01960784	0.01960784
2004	UT73-04	46	83	85	84	0.02380952	0.02380952	97	98	97.5	0.01025641	0.01025641
2006	UT46-06	46	86	86	86	0	0	89	87	88	-0.0227273	0.02272727
2007	UT107-0	46	83	85	84	0.02380952	0.02380952	89	90	89.5	0.01117318	0.01117318
2007	UT11-07	47	84	84	84	0	0	89	91	90	0.02222222	0.02222222
2007	UT29-07	49	83	83	83	0	0	90	91	90.5	0.01104972	0.01104972
2006	UT08-06	50	85	86	85.5	0.01169591	0.01169591	90	89	89.5	-0.0111732	0.01117318
2008	UT49-08	50	84	84	84	0	0	90	92	91	0.02197802	0.02197802
2007	UT83-07	50	86	88	87	0.02298851	0.02298851	96	94	95	-0.0210526	0.02105263
2007	UT38-07	51	82	82	82	0	0	99	100	99.5	0.01005025	0.01005025
2008	UT04-08	51	78	78	78	0	0	93	94	93.5	0.01069519	0.01069519
2007	UT116-07	53	82	81	81.5	-0.0122699	0.01226994	95	93	94	-0.0212766	0.0212766
2005	UT78-05	53	88	89	88.5	0.01129944	0.01129944	93	91	92	-0.0217391	0.02173913
2008	UT05-08	53	84	85	84.5	0.01183432	0.01183432	85	85	85	0	0
2007	UT12-07	53	91	91	91	0	0	89	88	88.5	-0.0112994	0.01129944
2007	UT63-07	53	82	81	81.5	-0.0122699	0.01226994	93	90	91.5	-0.0327869	0.03278689
2007	UT99-07	54						91	91	91	0	0
2007	UT21-07	54	84	84	84	0	0	93	93	93	0	0
2007	UT58-07	54	90	90	90	0	0	100	98	99	-0.020202	0.02020202
2007	UT88-07	54	86	86	86	0	0	87	86	86.5	-0.0115607	0.01156069
2007	UT110-07	54	86	86	86	0	0	89	87	88	-0.0227273	0.02272727
2008	UT117-08	54	90	89	89.5	-0.0111732	0.01117318	89	88	88.5	-0.0112994	0.01129944
2006	UT80-06	55	80	80	80	0	0	89	90	89.5	0.01117318	0.01117318
2005	UT72-05	55	88	88	88	0	0	88	85	86.5	-0.0346821	0.03468208
2008	UT18-08	56	88	88	88	0	0	86	87	86.5	0.01156069	0.01156069
2006	UT34-06	56	85	85	85	0	0	99	98	98.5	-0.0101523	0.01015228
2006	UT43-06	57	85	85	85	0	0	81	80	80.5	-0.0124224	0.01242236
2006	UT72-06	57	86	86	86	0	0	88	87	87.5	-0.0114286	0.01142857
2008	UT30-08	58	84	83	83.5	-0.011976	0.01197605	85	87	86	0.02325581	0.02325581
2006	UT19-06	59	79	81	80	0.025	0.025	87	87	87	0	0
2007	UT46-07	59	81	84	82.5	0.03636364	0.03636364	96	96	96	0	0
2007	UT73-07	59	85	86	85.5	0.01169591	0.01169591	92	88	90	-0.0444444	0.04444444
2002	UT07-02	59	85	86	85.5	0.01169591	0.01169591	88	88	88	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	FEMEBRL	FEMEBRR	Mean	%DA	ABS	FEMCIRL	FEMCIRR	Mean	%DA	ABS
2007	UT48-07	60	88	88	88	0	0	90	91	90.5	0.01104972	0.01104972
2006	UT97-06	61	80	81	80.5	0.01242236	0.01242236	96	95	95.5	-0.0104712	0.0104712
2007	UT36-07	61	91	91	91	0	0	93	95	94	0.0212766	0.0212766
2004	UT63-04	61	84	85	84.5	0.01183432	0.01183432	93	91	92	-0.0217391	0.02173913
2007	UT64-07	61	84	86	85	0.02352941	0.02352941	94	88	91	-0.0659341	0.06593407
2006	UT50-06	62	84	85	84.5	0.01183432	0.01183432	102	102	102	0	0
2005	UT70-05	62	88	87	87.5	-0.0114286	0.01142857	86	87	86.5	0.01156069	0.01156069
2006	UT86-06	62	88	88	88	0	0	90	93	91.5	0.03278689	0.03278689
2007	UT65-07	63	87	88	87.5	0.01142857	0.01142857	91	91	91	0	0
2006	UT31-06	63	86	86	86	0	0	90	91	90.5	0.01104972	0.01104972
2005	UT73-05	63	88	89	88.5	0.01129944	0.01129944	92	93	92.5	0.01081081	0.01081081
2007	UT43-07	64	79	80	79.5	0.01257862	0.01257862	95	96	95.5	0.0104712	0.0104712
2007	UT87-07	64	87	89	88	0.02272727	0.02272727	95	97	96	0.02083333	0.02083333
2008	UT14-08	64	91	92	91.5	0.01092896	0.01092896	89	89	89	0	0
2008	UT53-08	65	83	84	83.5	0.01197605	0.01197605	92	90	91	-0.021978	0.02197802
2007	UT103-0	66	90	91	90.5	0.01104972	0.01104972	98	92	95	-0.0631579	0.06315789
2008	UT118-08	67	87	87	87	0	0	90	92	91	0.02197802	0.02197802
2006	UT35-06	67	85	86	85.5	0.01169591	0.01169591	97	98	97.5	0.01025641	0.01025641
2007	UT22-07	67	91	91	91	0	0	103	103	103	0	0
2005	UT89-05	68	82	82	82	0	0	95	95	95	0	0
2007	UT85-07	68	94	95	94.5	0.01058201	0.01058201	84	84	84	0	0
2007	UT104-0	68	87	87	87	0	0	93	93	93	0	0
2008	UT38-08	69	86	84	85	-0.0235294	0.02352941	96	91	93.5	-0.0534759	0.05347594
2008	UT39-08	70	82	81	81.5	-0.0122699	0.01226994	95	94	94.5	-0.010582	0.01058201
2007	UT42-07	70	90	91	90.5	0.01104972	0.01104972	96	94	95	-0.0210526	0.02105263
2006	UT16-06	70	82	83	82.5	0.01212121	0.01212121	95	94	94.5	-0.010582	0.01058201
2008	UT09-08	70	85	85	85	0	0	87	85	86	-0.0232558	0.02325581
2006	UT103-06	71						102	99	100.5	-0.0298507	0.02985075
2007	UT84-07	71	90	90	90	0	0	104	100	102	-0.0392157	0.03921569
2006	UT01-06	71	92	92	92	0	0	103	104	103.5	0.00966184	0.00966184
2006	UT76-06	71	86	86	86	0	0	107	98	102.5	-0.0878049	0.08780488
2006	UT07-06	71	87	87	87	0	0	92	92	92	0	0
2008	UT34-08	72	86	86	86	0	0	94	94	94	0	0
2003	UT64-03	72	79	80	79.5	0.01257862	0.01257862	96	97	96.5	0.01036269	0.01036269
2007	UT49-07	73	87	88	87.5	0.01142857	0.01142857	91	93	92	0.02173913	0.02173913
2007	UT47-07	74	92	92	92	0	0	92	93	92.5	0.01081081	0.01081081
2008	UT01-08	77	91	91	91	0	0	91	90	90.5	-0.0110497	0.01104972
2008	UT65-08	78	93	93	93	0	0	105	105	105	0	0
2007	UT72-07	79	83	83	83	0	0	96	98	97	0.02061856	0.02061856
2007	UT02-07	80	79	79	79	0	0	94	93	93.5	-0.0106952	0.01069519
2008	UT42-08	80	84	85	84.5	0.01183432	0.01183432	96	96	96	0	0
2008	UT90-08	81	92	94	93	0.02150538	0.02150538	85	84	84.5	-0.0118343	0.01183432
2007	UT06-07	81	83	83	83	0	0	92	92	92	0	0
2006	UT71-06	81	87	89	88	0.02272727	0.02272727	90	90	90	0	0
2008	UT103-08	82	86	87	86.5	0.01156069	0.01156069	95	95	95	0	0
2008	UT46-08	82	90	91	90.5	0.01104972	0.01104972	85	84	84.5	-0.0118343	0.01183432
2004	UT65-04	82	80	80	80	0	0	84	84	84	0	0
2008	UT114-08	82	85	84	84.5	-0.0118343	0.01183432	91	89	90	-0.0222222	0.02222222
2006	UT82-06	84	82	83	82.5	0.01212121	0.01212121	91	91	91	0	0
2006	UT13-06	90	79	80	79.5	0.01257862	0.01257862	87	89	88	0.02272727	0.02272727

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	TIBXLNL	TIBXLNR	Mean	%DA	ABS	TIBPEBL	TIBPEBR	Mean	%DA	ABS
2006	UT65-06	31	365	365	365	0	0	82	82	82	0	0
2009	UT92-09	33						73	75	74	0.02702703	0.02702703
2001	UT32-01	33	391	390	390.5	-0.0025608	0.00256082	82	84	83	0.02409639	0.02409639
2007	UT50-07	38	402	399	400.5	-0.0074906	0.00749064	75	74	74.5	-0.0134228	0.01342282
2008	UT100-08	39	403	403	403	0	0	79	77	78	-0.025641	0.02564103
2006	UT47-06	39	385	384	384.5	-0.0026008	0.00260078	81	82	81.5	0.01226994	0.01226994
2008	UT15-08	39	371	374	372.5	0.00805369	0.00805369	79	78	78.5	-0.0127389	0.01273885
2006	UT70-06	42	370	372	371	0.00539084	0.00539084	80	81	80.5	0.01242236	0.01242236
2008	UT104-08	43	405	404	404.5	-0.0024722	0.00247219	81	79	80	-0.025	0.025
2006	UT63-06	43	414	420	417	0.01438849	0.01438849	76	76	76	0	0
2006	UT64-06	43	366	362	364	-0.010989	0.01098901	79	79	79	0	0
2007	UT89-07	43	430	434	432	0.00925926	0.00925926	79	80	79.5	0.01257862	0.01257862
2006	UT49-06	44	415	414	414.5	-0.0024125	0.00241255	79	79	79	0	0
2007	UT114-07	44	392	399	395.5	0.01769912	0.01769912	83	81	82	-0.0243902	0.02439024
2007	UT53-07	44	419	417	418	-0.0047847	0.00478469	81	80	80.5	-0.0124224	0.01242236
2007	UT53-07	44	391	390	390.5	-0.0025608	0.00256082	78	77	77.5	-0.0129032	0.01290323
2005	UT81-05	45	383	383	383	0	0	81	80	80.5	-0.0124224	0.01242236
2008	UT07-08	46	383	384	383.5	0.00260756	0.00260756	76	78	77	0.02597403	0.02597403
2004	UT73-04	46	418	417	417.5	-0.0023952	0.00239521					
2006	UT46-06	46	387	389	388	0.00515464	0.00515464	77	78	77.5	0.01290323	0.01290323
2007	UT107-0	46	356	352	354	-0.0112994	0.01129944	80	80	80	0	0
2007	UT11-07	47	406	408	407	0.004914	0.004914	83	81	82	-0.0243902	0.02439024
2007	UT29-07	49	346	346	346	0	0					
2006	UT08-06	50	405	404	404.5	-0.0024722	0.00247219	76	75	75.5	-0.013245	0.01324503
2008	UT49-08	50	375	375	375	0	0	77	77	77	0	0
2007	UT83-07	50	352	347	349.5	-0.0143062	0.01430615	81	81	81	0	0
2007	UT38-07	51	380	377	378.5	-0.007926	0.00792602	79	79	79	0	0
2008	UT04-08	51	374	375	374.5	0.00267023	0.00267023					
2007	UT116-07	53	352	352	352	0	0	77	76	76.5	-0.0130719	0.0130719
2005	UT78-05	53	359	360	359.5	0.00278164	0.00278164	83	84	83.5	0.01197605	0.01197605
2008	UT05-08	53	379	377	378	-0.005291	0.00529101	78	78	78	0	0
2007	UT12-07	53										
2007	UT63-07	53	383	387	385	0.01038961	0.01038961	76	78	77	0.02597403	0.02597403
2007	UT99-07	54						84	84	84	0	0
2007	UT21-07	54	412	416	414	0.00966184	0.00966184	80	79	79.5	-0.0125786	0.01257862
2007	UT58-07	54	393	399	396	0.01515152	0.01515152	82	81	81.5	-0.0122699	0.01226994
2007	UT88-07	54	424	424	424	0	0					
2007	UT110-07	54	407	413	410	0.01463415	0.01463415	78	78	78	0	0
2008	UT117-08	54	430	435	432.5	0.01156069	0.01156069	77	78	77.5	0.01290323	0.01290323
2006	UT80-06	55	403	397	400	-0.015	0.015	82	84	83	0.02409639	0.02409639
2005	UT72-05	55	418	418	418	0	0	77	76	76.5	-0.0130719	0.0130719
2008	UT18-08	56	414	416	415	0.00481928	0.00481928	82	82	82	0	0
2006	UT34-06	56	393	394	393.5	0.0025413	0.0025413					
2006	UT43-06	57	438	438	438	0	0	79	80	79.5	0.01257862	0.01257862
2006	UT72-06	57	403	408	405.5	0.01233046	0.01233046	84	83	83.5	-0.011976	0.01197605
2008	UT30-08	58	368	371	369.5	0.00811908	0.00811908	73	73	73	0	0
2006	UT19-06	59	415	408	411.5	-0.0170109	0.01701094	81	81	81	0	0
2007	UT46-07	59	425	424	424.5	-0.0023557	0.00235571					
2007	UT73-07	59	372	374	373	0.00536193	0.00536193	87	86	86.5	-0.0115607	0.01156069
2002	UT07-02	59	424	422	423	-0.0047281	0.00472813	80	79	79.5	-0.0125786	0.01257862

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	TIBXLNL	TIBXLNR	Mean	%DA	ABS	TIBPEBL	TIBPEBR	Mean	%DA	ABS
2007	UT48-07	60	421	425	423	0.00945626	0.00945626	84	83	83.5	-0.011976	0.01197605
2006	UT97-06	61	388	392	390	0.01025641	0.01025641	79	80	79.5	0.01257862	0.01257862
2007	UT36-07	61	431	431	431	0	0	78	78	78	0	0
2004	UT63-04	61	415	425	420	0.02380952	0.02380952	83	83	83	0	0
2007	UT64-07	61	366	359	362.5	-0.0193103	0.01931034	80	80	80	0	0
2006	UT50-06	62	389	387	388	-0.0051546	0.00515464	82	83	82.5	0.01212121	0.01212121
2005	UT70-05	62	371	371	371	0	0					
2006	UT86-06	62	420	419	419.5	-0.0023838	0.00238379	74	74	74	0	0
2007	UT65-07	63	380	383	381.5	0.0078637	0.0078637	76	77	76.5	0.0130719	0.0130719
2006	UT31-06	63	392	390	391	-0.0051151	0.00511509	75	75	75	0	0
2005	UT73-05	63	371	377	374	0.01604278	0.01604278	85	84	84.5	-0.0118343	0.01183432
2007	UT43-07	64	384	391	387.5	0.01806452	0.01806452	72	72	72	0	0
2007	UT87-07	64						80	80	80	0	0
2008	UT14-08	64	386	385	385.5	-0.002594	0.00259403	87	86	86.5	-0.0115607	0.01156069
2008	UT53-08	65	364	366	365	0.00547945	0.00547945	85	86	85.5	0.01169591	0.01169591
2007	UT103-0	66	375	374	374.5	-0.0026702	0.00267023	80	80	80	0	0
2008	UT118-08	67	389	397	393	0.02035623	0.02035623	79	76	77.5	-0.0387097	0.03870968
2006	UT35-06	67	352	355	353.5	0.00848656	0.00848656	85	85	85	0	0
2007	UT22-07	67	376	376	376	0	0					
2005	UT89-05	68						81	81	81	0	0
2007	UT85-07	68	421	420	420.5	-0.0023781	0.00237812	78	80	79	0.02531646	0.02531646
2007	UT104-0	68	395	391	393	-0.0101781	0.01017812	81	81	81	0	0
2008	UT38-08	69	353	353	353	0	0	77	78	77.5	0.01290323	0.01290323
2008	UT39-08	70	361	356	358.5	-0.013947	0.013947					
2007	UT42-07	70	377	382	379.5	0.01317523	0.01317523	78	77	77.5	-0.0129032	0.01290323
2006	UT16-06	70	372	372	372	0	0	79	80	79.5	0.01257862	0.01257862
2008	UT09-08	70						86	87	86.5	0.01156069	0.01156069
2006	UT103-06	71	386	386	386	0	0	84	84	84	0	0
2007	UT84-07	71	381	386	383.5	0.01303781	0.01303781	79	78	78.5	-0.0127389	0.01273885
2006	UT01-06	71	397	396	396.5	-0.0025221	0.00252207	88	90	89	0.02247191	0.02247191
2006	UT76-06	71	372	375	373.5	0.00803213	0.00803213	78	78	78	0	0
2006	UT07-06	71	406	409	407.5	0.00736196	0.00736196	79	80	79.5	0.01257862	0.01257862
2008	UT34-08	72	412	408	410	-0.0097561	0.0097561	79	78	78.5	-0.0127389	0.01273885
2003	UT64-03	72	403	408	405.5	0.01233046	0.01233046	81	82	81.5	0.01226994	0.01226994
2007	UT49-07	73	382	386	384	0.01041667	0.01041667	76	75	75.5	-0.013245	0.01324503
2007	UT47-07	74	405	408	406.5	0.00738007	0.00738007	85	82	83.5	-0.0359281	0.03592814
2008	UT01-08	77	407	407	407	0	0	74	70	72	-0.0555556	0.05555556
2008	UT65-08	78	373	374	373.5	0.00267738	0.00267738	81	81	81	0	0
2007	UT72-07	79	428	429	428.5	0.00233372	0.00233372	78	76	77	-0.025974	0.02597403
2007	UT02-07	80	378	379	378.5	0.00264201	0.00264201	82	81	81.5	-0.0122699	0.01226994
2008	UT42-08	80	380	381	380.5	0.00262812	0.00262812	78	78	78	0	0
2008	UT90-08	81	366	361	363.5	-0.0137552	0.01375516	82	81	81.5	-0.0122699	0.01226994
2007	UT06-07	81	383	382	382.5	-0.0026144	0.00261438	82	82	82	0	0
2006	UT71-06	81	390	393	391.5	0.00766284	0.00766284	85	86	85.5	0.01169591	0.01169591
2008	UT103-08	82	425	418	421.5	-0.0166074	0.01660735	83	83	83	0	0
2008	UT46-08	82	363	365	364	0.00549451	0.00549451	81	81	81	0	0
2004	UT65-04	82	398	399	398.5	0.00250941	0.00250941					
2008	UT114-08	82	396	399	397.5	0.00754717	0.00754717	83	83	83	0	0
2006	UT82-06	84	402	401	401.5	-0.0024907	0.00249066	76	78	77	0.02597403	0.02597403
2006	UT13-06	90	385	392	388.5	0.01801802	0.01801802	80	80	80	0	0

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	TIBDEBL	TIBDEBR	Mean	%DA	ABS	TIBNFXL	TIBNFXR	Mean	%DA	ABS
2006	UT65-06	31	52	52	52	0	0	34	38	36	0.11111111	0.11111111
2009	UT92-09	33						38	38	38	0	0
2001	UT32-01	33	48	50	49	0.04081633	0.04081633	39	41	40	0.05	0.05
2007	UT50-07	38	51	50	50.5	-0.019802	0.01980198	40	41	40.5	0.02469136	0.02469136
2008	UT100-08	39	51	50	50.5	-0.019802	0.01980198	33	34	33.5	0.02985075	0.02985075
2006	UT47-06	39	48	49	48.5	0.02061856	0.02061856	34	35	34.5	0.02898551	0.02898551
2008	UT15-08	39	48	48	48	0	0	34	37	35.5	0.08450704	0.08450704
2006	UT70-06	42	48	49	48.5	0.02061856	0.02061856	32	30	31	-0.0645161	0.06451613
2008	UT104-08	43						37	40	38.5	0.07792208	0.07792208
2006	UT63-06	43	49	49	49	0	0	38	36	37	-0.0540541	0.05405405
2006	UT64-06	43	49	48	48.5	-0.0206186	0.02061856	31	30	30.5	-0.0327869	0.03278689
2007	UT89-07	43	50	50	50	0	0	41	44	42.5	0.07058824	0.07058824
2006	UT49-06	44	47	47	47	0	0	35	36	35.5	0.02816901	0.02816901
2007	UT114-07	44	45	44	44.5	-0.0224719	0.02247191	38	36	37	-0.0540541	0.05405405
2007	UT53-07	44	50	50	50	0	0	34	33	33.5	-0.0298507	0.02985075
2007	UT53-07	44	47	52	49.5	0.1010101	0.1010101	42	43	42.5	0.02352941	0.02352941
2005	UT81-05	45	51	52	51.5	0.01941748	0.01941748	39	38	38.5	-0.025974	0.02597403
2008	UT07-08	46	54	53	53.5	-0.0186916	0.01869159	40	41	40.5	0.02469136	0.02469136
2004	UT73-04	46	47	46	46.5	-0.0215054	0.02150538	41	41	41	0	0
2006	UT46-06	46	46	47	46.5	0.02150538	0.02150538	34	36	35	0.05714286	0.05714286
2007	UT107-0	46	51	50	50.5	-0.019802	0.01980198	33	34	33.5	0.02985075	0.02985075
2007	UT11-07	47	51	50	50.5	-0.019802	0.01980198	37	35	36	-0.0555556	0.05555556
2007	UT29-07	49	50	50	50	0	0	37	39	38	0.05263158	0.05263158
2006	UT08-06	50					0	37	36	36.5	-0.0273973	0.02739726
2008	UT49-08	50	52	53	52.5	0.01904762	0.01904762	38	39	38.5	0.02597403	0.02597403
2007	UT83-07	50	50	50	50	0	0	36	37	36.5	0.02739726	0.02739726
2007	UT38-07	51	45	45	45	0	0	34	35	34.5	0.02898551	0.02898551
2008	UT04-08	51	49	49	49	0	0	37	38	37.5	0.02666667	0.02666667
2007	UT116-07	53	47	48	47.5	0.02105263	0.02105263	40	39	39.5	-0.0253165	0.02531646
2005	UT78-05	53	51	51	51	0	0	34	34	34	0	0
2008	UT05-08	53	45	45	45	0	0	32	34	33	0.06060606	0.06060606
2007	UT12-07	53	51	50	50.5	-0.019802	0.01980198	37	36	36.5	-0.0273973	0.02739726
2007	UT63-07	53	48	50	49	0.04081633	0.04081633	38	42	40	0.1	0.1
2007	UT99-07	54	51	51	51	0	0	35	37	36	0.05555556	0.05555556
2007	UT21-07	54	46	47	46.5	0.02150538	0.02150538	35	37	36	0.05555556	0.05555556
2007	UT58-07	54	51	52	51.5	0.01941748	0.01941748	36	34	35	-0.0571429	0.05714286
2007	UT88-07	54	49	48	48.5	-0.0206186	0.02061856	33	30	31.5	-0.0952381	0.0952381
2007	UT110-07	54	52	52	52	0	0	33	35	34	0.05882353	0.05882353
2008	UT117-08	54	49	49	49	0	0	33	32	32.5	-0.0307692	0.03076923
2006	UT80-06	55						35	33	34	-0.0588235	0.05882353
2005	UT72-05	55	46	48	47	0.04255319	0.04255319	35	35	35	0	0
2008	UT18-08	56	47	46	46.5	-0.0215054	0.02150538	37	38	37.5	0.02666667	0.02666667
2006	UT34-06	56	51	50	50.5	-0.019802	0.01980198	34	35	34.5	0.02898551	0.02898551
2006	UT43-06	57	48	49	48.5	0.02061856	0.02061856	34	33	33.5	-0.0298507	0.02985075
2006	UT72-06	57	54	53	53.5	-0.0186916	0.01869159	33	33	33	0	0
2008	UT30-08	58	51	52	51.5	0.01941748	0.01941748	37	38	37.5	0.02666667	0.02666667
2006	UT19-06	59	50	49	49.5	-0.020202	0.02020202	36	35	35.5	-0.028169	0.02816901
2007	UT46-07	59	51	51	51	0	0	35	33	34	-0.0588235	0.05882353
2007	UT73-07	59	48	47	47.5	-0.0210526	0.02105263	38	40	39	0.05128205	0.05128205
2002	UT07-02	59	53	53	53	0	0	34	33	33.5	-0.0298507	0.02985075

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	TIBDEBL	TIBDEBR	Mean	%DA	ABS	TIBNFXL	TIBNFXR	Mean	%DA	ABS
2007	UT48-07	60	52	53	52.5	0.01904762	0.01904762	39	36	37.5	-0.08	0.08
2006	UT97-06	61	51	53	52	0.03846154	0.03846154	39	39	39	0	0
2007	UT36-07	61	49	48	48.5	-0.0206186	0.02061856	39	40	39.5	0.02531646	0.02531646
2004	UT63-04	61	46	48	47	0.04255319	0.04255319	36	37	36.5	0.02739726	0.02739726
2007	UT64-07	61	48	51	49.5	0.06060606	0.06060606	36	35	35.5	-0.028169	0.02816901
2006	UT50-06	62	57	56	56.5	-0.0176991	0.01769912	43	45	44	0.04545455	0.04545455
2005	UT70-05	62	51	51	51	0	0	34	36	35	0.05714286	0.05714286
2006	UT86-06	62	50	52	51	0.03921569	0.03921569	37	36	36.5	-0.0273973	0.02739726
2007	UT65-07	63	52	51	51.5	-0.0194175	0.01941748	36	37	36.5	0.02739726	0.02739726
2006	UT31-06	63	55	54	54.5	-0.0183486	0.01834862	40	42	41	0.04878049	0.04878049
2005	UT73-05	63	54	54	54	0	0	34	37	35.5	0.08450704	0.08450704
2007	UT43-07	64	48	48	48	0	0	37	36	36.5	-0.0273973	0.02739726
2007	UT87-07	64	50	47	48.5	-0.0618557	0.06185567	37	36	36.5	-0.0273973	0.02739726
2008	UT14-08	64	54	52	53	-0.0377358	0.03773585	36	36	36	0	0
2008	UT53-08	65						41	39	40	-0.05	0.05
2007	UT103-0	66	48	50	49	0.04081633	0.04081633	32	32	32	0	0
2008	UT118-08	67	51	51	51	0	0	38	38	38	0	0
2006	UT35-06	67	59	60	59.5	0.01680672	0.01680672	33	33	33	0	0
2007	UT22-07	67						38	39	38.5	0.02597403	0.02597403
2005	UT89-05	68	53	53	53	0	0	39	40	39.5	0.02531646	0.02531646
2007	UT85-07	68	51	49	50	-0.04	0.04	36	40	38	0.10526316	0.10526316
2007	UT104-0	68	53	54	53.5	0.01869159	0.01869159	34	33	33.5	-0.0298507	0.02985075
2008	UT38-08	69	51	51	51	0	0	38	39	38.5	0.02597403	0.02597403
2008	UT39-08	70	51	51	51	0	0	41	43	42	0.04761905	0.04761905
2007	UT42-07	70						36	35	35.5	-0.028169	0.02816901
2006	UT16-06	70	55	55	55	0	0	32	32	32	0	0
2008	UT09-08	70	53	55	54	0.03703704	0.03703704	34	35	34.5	0.02898551	0.02898551
2006	UT103-06	71	51	51	51	0	0	33	34	33.5	0.02985075	0.02985075
2007	UT84-07	71	49	50	49.5	0.02020202	0.02020202	38	38	38	0	0
2006	UT01-06	71	50	49	49.5	-0.020202	0.02020202	41	41	41	0	0
2006	UT76-06	71	53	51	52	-0.0384615	0.03846154	37	39	38	0.05263158	0.05263158
2006	UT07-06	71	48	51	49.5	0.06060606	0.06060606	37	37	37	0	0
2008	UT34-08	72	49	50	49.5	0.02020202	0.02020202	36	36	36	0	0
2003	UT64-03	72	50	51	50.5	0.01980198	0.01980198	39	39	39	0	0
2007	UT49-07	73	51	51	51	0	0	35	36	35.5	0.02816901	0.02816901
2007	UT47-07	74	46	47	46.5	0.02150538	0.02150538	38	37	37.5	-0.0266667	0.02666667
2008	UT01-08	77	51	50	50.5	-0.019802	0.01980198	36	37	36.5	0.02739726	0.02739726
2008	UT65-08	78	48	48	48	0	0	31	31	31	0	0
2007	UT72-07	79	54	53	53.5	-0.0186916	0.01869159	34	35	34.5	0.02898551	0.02898551
2007	UT02-07	80	48	49	48.5	0.02061856	0.02061856	37	37	37	0	0
2008	UT42-08	80	54	53	53.5	-0.0186916	0.01869159	32	33	32.5	0.03076923	0.03076923
2008	UT90-08	81	54	55	54.5	0.01834862	0.01834862	37	37	37	0	0
2007	UT06-07	81	59	57	58	-0.0344828	0.03448276	35	35	35	0	0
2006	UT71-06	81						42	42	42	0	0
2008	UT103-08	82	48	48	48	0	0	38	37	37.5	-0.0266667	0.02666667
2008	UT46-08	82	50	51	50.5	0.01980198	0.01980198	39	42	40.5	0.07407407	0.07407407
2004	UT65-04	82	47	49	48	0.04166667	0.04166667	41	41	41	0	0
2008	UT114-08	82	50	47	48.5	-0.0618557	0.06185567	39	38	38.5	-0.025974	0.02597403
2006	UT82-06	84						37	39	38	0.05263158	0.05263158
2006	UT13-06	90	52	51	51.5	-0.0194175	0.01941748	35	36	35.5	0.02816901	0.02816901

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	TIBNFTL	TIBNFTR	Mean	%DA	ABS	TIBCIRL	TIBCIRR	Mean	%DA	ABS
2006	UT65-06	31	25	25	25	0	0	104	107	105.5	0.02843602	0.02843602
2009	UT92-09	33	24	24	24	0	0	100	101	100.5	0.00995025	0.00995025
2001	UT32-01	33	25	24	24.5	-0.0408163	0.04081633	94	96	95	0.02105263	0.02105263
2007	UT50-07	38	24	26	25	0.08	0.08	90	90	90	0	0
2008	UT100-08	39	24	23	23.5	-0.0425532	0.04255319	105	104	104.5	-0.0095694	0.00956938
2006	UT47-06	39	19	19	19	0	0	104	103	103.5	-0.0096618	0.00966184
2008	UT15-08	39	23	23	23	0	0	96	95	95.5	-0.0104712	0.0104712
2006	UT70-06	42	25	26	25.5	0.03921569	0.03921569	90	93	91.5	0.03278689	0.03278689
2008	UT104-08	43	30	29	29.5	-0.0338983	0.03389831	80	80	80	0	0
2006	UT63-06	43	26	26	26	0	0	109	110	109.5	0.00913242	0.00913242
2006	UT64-06	43	27	25	26	-0.0769231	0.07692308	93	95	94	0.0212766	0.0212766
2007	UT89-07	43	24	25	24.5	0.04081633	0.04081633	87	89	88	0.02272727	0.02272727
2006	UT49-06	44	25	25	25	0	0	94	94	94	0	0
2007	UT114-07	44	25	25	25	0	0	109	108	108.5	-0.0092166	0.00921659
2007	UT53-07	44	31	31	31	0	0	91	90	90.5	-0.0110497	0.01104972
2007	UT53-07	44	27	26	26.5	-0.0377358	0.03773585	92	94	93	0.02150538	0.02150538
2005	UT81-05	45	28	27	27.5	-0.0363636	0.03636364	95	93	94	-0.0212766	0.0212766
2008	UT07-08	46	24	25	24.5	0.04081633	0.04081633	105	105	105	0	0
2004	UT73-04	46	25	25	25	0	0	105	104	104.5	-0.0095694	0.00956938
2006	UT46-06	46	26	27	26.5	0.03773585	0.03773585	101	100	100.5	-0.0099502	0.00995025
2007	UT107-0	46	23	22	22.5	-0.0444444	0.04444444	101	98	99.5	-0.0301508	0.03015075
2007	UT11-07	47	24	25	24.5	0.04081633	0.04081633	89	91	90	0.02222222	0.02222222
2007	UT29-07	49	23	25	24	0.08333333	0.08333333	89	84	86.5	-0.0578035	0.05780347
2006	UT08-06	50	24	24	24	0	0	96	94	95	-0.0210526	0.02105263
2008	UT49-08	50	25	23	24	-0.0833333	0.08333333	100	103	101.5	0.02955665	0.02955665
2007	UT83-07	50	26	27	26.5	0.03773585	0.03773585	94	97	95.5	0.03141361	0.03141361
2007	UT38-07	51	24	26	25	0.08	0.08	90	90	90	0	0
2008	UT04-08	51	24	25	24.5	0.04081633	0.04081633	93	92	92.5	-0.0108108	0.01081081
2007	UT116-07	53	28	28	28	0	0	94	94	94	0	0
2005	UT78-05	53	28	29	28.5	0.03508772	0.03508772	105	105	105	0	0
2008	UT05-08	53	25	27	26	0.07692308	0.07692308	100	101	100.5	0.00995025	0.00995025
2007	UT12-07	53	26	26	26	0	0	92	91	91.5	-0.010929	0.01092896
2007	UT63-07	53	24	25	24.5	0.04081633	0.04081633	91	94	92.5	0.03243243	0.03243243
2007	UT99-07	54	23	23	23	0	0	83	82	82.5	-0.0121212	0.01212121
2007	UT21-07	54	24	23	23.5	-0.0425532	0.04255319	108	110	109	0.01834862	0.01834862
2007	UT58-07	54	23	23	23	0	0	97	95	96	-0.0208333	0.02083333
2007	UT88-07	54	24	24	24	0	0	94	96	95	0.02105263	0.02105263
2007	UT110-07	54	26	25	25.5	-0.0392157	0.03921569	92	95	93.5	0.03208556	0.03208556
2008	UT117-08	54	28	30	29	0.06896552	0.06896552	92	97	94.5	0.05291005	0.05291005
2006	UT80-06	55	27	27	27	0	0	93	93	93	0	0
2005	UT72-05	55	28	28	28	0	0	100	98	99	-0.020202	0.02020202
2008	UT18-08	56	27	27	27	0	0	90	91	90.5	0.01104972	0.01104972
2006	UT34-06	56	26	27	26.5	0.03773585	0.03773585	90	89	89.5	-0.0111732	0.01117318
2006	UT43-06	57	26	27	26.5	0.03773585	0.03773585	108	113	110.5	0.04524887	0.04524887
2006	UT72-06	57	24	25	24.5	0.04081633	0.04081633	100	106	103	0.05825243	0.05825243
2008	UT30-08	58	23	23	23	0	0	101	101	101	0	0
2006	UT19-06	59	25	25	25	0	0	95	95	95	0	0
2007	UT46-07	59	26	26	26	0	0	101	101	101	0	0
2007	UT73-07	59	26	28	27	0.07407407	0.07407407	106	108	107	0.01869159	0.01869159
2002	UT07-02	59	26	25	25.5	-0.0392157	0.03921569	99	97	98	-0.0204082	0.02040816

Appendix A: Database-derived measurements for complete sample, continued

YEAR	UTID	AGE	TIBNFTL	TIBNFTR	Mean	%DA	ABS	TIBCIRL	TIBCIRR	Mean	%DA	ABS
2007	UT48-07	60	25	24	24.5	-0.0408163	0.04081633	92	94	93	0.02150538	0.02150538
2006	UT97-06	61	26	27	26.5	0.03773585	0.03773585	100	102	101	0.01980198	0.01980198
2007	UT36-07	61	25	24	24.5	-0.0408163	0.04081633	93	91	92	-0.0217391	0.02173913
2004	UT63-04	61	23	22	22.5	-0.0444444	0.04444444	94	97	95.5	0.03141361	0.03141361
2007	UT64-07	61	19	18	18.5	-0.0540541	0.05405405	92	95	93.5	0.03208556	0.03208556
2006	UT50-06	62	29	28	28.5	-0.0350877	0.03508772	95	96	95.5	0.0104712	0.0104712
2005	UT70-05	62	28	29	28.5	0.03508772	0.03508772	92	91	91.5	-0.010929	0.01092896
2006	UT86-06	62	24	25	24.5	0.04081633	0.04081633	109	106	107.5	-0.027907	0.02790698
2007	UT65-07	63	24	24	24	0	0	97	98	97.5	0.01025641	0.01025641
2006	UT31-06	63	28	29	28.5	0.03508772	0.03508772	88	89	88.5	0.01129944	0.01129944
2005	UT73-05	63	29	26	27.5	-0.1090909	0.10909091	97	103	100	0.06	0.06
2007	UT43-07	64	24	24	24	0	0	96	96	96	0	0
2007	UT87-07	64	26	28	27	0.07407407	0.07407407	91	88	89.5	-0.0335196	0.03351955
2008	UT14-08	64	24	26	25	0.08	0.08	94	98	96	0.04166667	0.04166667
2008	UT53-08	65	22	24	23	0.08695652	0.08695652	98	103	100.5	0.04975124	0.04975124
2007	UT103-0	66	24	25	24.5	0.04081633	0.04081633	102	99	100.5	-0.0298507	0.02985075
2008	UT118-08	67	26	26	26	0	0	105	104	104.5	-0.0095694	0.00956938
2006	UT35-06	67	29	28	28.5	-0.0350877	0.03508772	92	91	91.5	-0.010929	0.01092896
2007	UT22-07	67	24	26	25	0.08	0.08	99	103	101	0.03960396	0.03960396
2005	UT89-05	68	24	24	24	0	0	90	90	90	0	0
2007	UT85-07	68	31	31	31	0	0	99	98	98.5	-0.0101523	0.01015228
2007	UT104-0	68	28	29	28.5	0.03508772	0.03508772	90	91	90.5	0.01104972	0.01104972
2008	UT38-08	69	26	26	26	0	0					
2008	UT39-08	70	28	28	28	0	0	94	94	94	0	0
2007	UT42-07	70	24	24	24	0	0	100	101	100.5	0.00995025	0.00995025
2006	UT16-06	70	22	22	22	0	0	98	97	97.5	-0.0102564	0.01025641
2008	UT09-08	70	25	27	26	0.07692308	0.07692308	100	104	102	0.03921569	0.03921569
2006	UT103-06	71	25	25	25	0	0					
2007	UT84-07	71	22	22	22	0	0	99	100	99.5	0.01005025	0.01005025
2006	UT01-06	71	26	27	26.5	0.03773585	0.03773585	98	100	99	0.02020202	0.02020202
2006	UT76-06	71	24	25	24.5	0.04081633	0.04081633	87	85	86	-0.0232558	0.02325581
2006	UT07-06	71	25	23	24	-0.0833333	0.08333333	89	93	91	0.04395604	0.04395604
2008	UT34-08	72	24	24	24	0	0	98	97	97.5	-0.0102564	0.01025641
2003	UT64-03	72	29	30	29.5	0.03389831	0.03389831	95	96	95.5	0.0104712	0.0104712
2007	UT49-07	73	24	24	24	0	0	98	99	98.5	0.01015228	0.01015228
2007	UT47-07	74	23	24	23.5	0.04255319	0.04255319	97	100	98.5	0.03045685	0.03045685
2008	UT01-08	77	26	27	26.5	0.03773585	0.03773585	105	103	104	-0.0192308	0.01923077
2008	UT65-08	78	28	28	28	0	0					
2007	UT72-07	79	27	26	26.5	-0.0377358	0.03773585	110	112	111	0.01801802	0.01801802
2007	UT02-07	80	24	24	24	0	0	110	111	110.5	0.00904977	0.00904977
2008	UT42-08	80	27	28	27.5	0.03636364	0.03636364	89	88	88.5	-0.0112994	0.01129944
2008	UT90-08	81	25	25	25	0	0	101	102	101.5	0.00985222	0.00985222
2007	UT06-07	81	25	24	24.5	-0.0408163	0.04081633	87	89	88	0.02272727	0.02272727
2006	UT71-06	81	22	24	23	0.08695652	0.08695652	92	88	90	-0.0444444	0.04444444
2008	UT103-08	82	28	28	28	0	0	104	104	104	0	0
2008	UT46-08	82	25	26	25.5	0.03921569	0.03921569	95	97	96	0.02083333	0.02083333
2004	UT65-04	82	22	23	22.5	0.04444444	0.04444444	94	97	95.5	0.03141361	0.03141361
2008	UT114-08	82	31	29	30	-0.0666667	0.06666667	88	91	89.5	0.03351955	0.03351955
2006	UT82-06	84	27	27	27	0	0	107	106	106.5	-0.0093897	0.00938967
2006	UT13-06	90	26	27	26.5	0.03773585	0.03773585	105	107	106	0.01886792	0.01886792

Appendix B: Measurements taken for subset of sample, for error rate analyses

		17	**19**	**21**	**23**	**25**	**5**	**7**	**9**	**14**	**11**
Year		**2007**	**2007**	**2007**	**2007**	**2007**	**2008**	**2008**	**2008**	**2008**	**2008**
UTID		**UT114-07**	**UT53-07**	**UT11-07**	**UT29-07**	**UT38-07**	**UT53-08**	**UT38-08**	**UT09-08**	**UT65-08**	**UT34-08**
Age		**44**	**44**	**47**	**49**	**51**	**65**	**69**	**70**	**78**	**72**
(R) Humerus											
	HUMXLN	323	331	293	322	348	322	328	339	313	335
	HUMBUE	56	54	51	53	54	54	52	51	51	54
	HUMEBR	64	64	62	68	73	71	64	67	65	63
	HUMHDD	48	48	45	47	52	48	46	46	47	47
	Midshaft	162	166	147	161	174	161	164	170	157	168
	HUMMXD	25	24	22	23	25	25	23	23	23	25
	HUMMWD	21	19	18	19	21	18	18	18	18	20
(L) Humerus											
	HUMXLN	322	330	294	320	345	324	327	338	315	330
	HUMBUE	54	53	51	53	54	55	52	51	50	53
	HUMEBR	65	63	62	65	73	70	64	66	66	60
	HUMHDD	49	48	45	46	51	48	47	44	47	47
	Midshaft	161	165	147	160	173	162	164	169	158	165
	HUMMXD	24	23	21	23	26	24	22	22	22	24
	HUMMWD	21	19	18	18	22	19	17	17	18	19
(R) Radius											
	RADXLN	254	260	230	261	275	252	254	265	240	257
	RADHDD	26	23	24	22	26	24	27	24	24	24
	Midshaft	127	130	115	131	138	126	127	133	120	129
	RADAPD	15	13	13	13	13	12	12	13	13	14
(L) Radius											
	RADXLN	253	262	231	260	272	250	258	261	239	253
	RADHDD	26	22	24	23	26	23	26	24	25	24
	Midshaft	127	131	116	130	136	125	129	131	120	127
	RADAPD	13	13	13	12	13	12	12	13	12	14
(R) Femur											
	FEMXLN	467	480	426	465	499	450	483	473	446	456
	FEMBLN	462	475	424	462	496	447	479	470	444	451
	FEMMAP	89	85	83	85	89	85	91	83	83	88
	FEMHDD	49	48	45	49	51	49	50	48	47	49
	Midshaft	234	240	213	233	250	225	242	237	223	228
	FEMMAP	32	31	26	33	33	33	29	32	31	35
	FEMMTV	31	25	27	29	28	30	28	29	27	27
	FEMCIR	100	87	80	98	99	99	90	93	89	97
(L) Femur											
	FEMXLN	464	483	430	469	499	451	486	472	450	461
	FEMBLN	460	479	428	466	497	450	481	470	447	458
	FEMMAP	88	85	82	86	89	86	91	83	85	91
	FEMHDD	48	48	46	48	52	49	50	48	47	49
	Midshaft	232	242	215	235	250	226	243	236	225	231
	FEMMAP	33	32	25	33	34	32	29	32	31	35
	FEMMTV	30	26	27	30	28	29	26	29	30	27
	FEMCIR	99	90	80	99	99	96	87	93	95	96
(R) Tibia											
	TIBXLN	397	391	355	391	427	378	391	404	363	381
	TIBPEB	82	74	79	82	82	81	85	79	77	83
	TIBDEB	52	45	47	52	52	52	51	52	51	50
	TIBNFX	43	33	33	40	36	37	33	40	36	40
	TIBNFT	31	24	25	23	26	25	24	25	25	26
	TIBCIR	115	91	90	100	97	98	90	101	96	101
(L) Tibia											
	TIBXLN	398	393	360	393	428	380	393	403	369	387
	TIBPEB	81	75	78	82	81	79	85	78	79	89
	TIBDEB	52	46	49	52	52	53	52	52	51	50
	TIBNFX	41	34	33	39	35	37	32	39	37	36
	TIBNFT	29	23	25	23	27	26	23	23	23	24
	TIBCIR	107	91	90	100	99	99	88	99	96	97

Appendix B: Measurements taken for subset of sample, for error rate analyses, continued

Year		**2007**	**2007**	**2007**	**2007**	**2007**	**2008**	**2008**	**2008**	**2008**	**2008**
UTID		**UT114-07**	**UT53-07**	**UT11-07**	**UT29-07**	**UT38-07**	**UT53-08**	**UT38-08**	**UT09-08**	**UT65-08**	**UT34-08**
Age		**44**	**44**	**47**	**49**	**51**	**65**	**69**	**70**	**78**	**72**
(R) Humerus											
	HUMXLN	324	331	293	321	348	321	328	338	313	335
	HUMBUE	55	53	50	52	55	55	52	51	52	53
	HUMEBR	65	64	62	68	72	70	62	66	65	62
	HUMHDD	50	48	46	46	50	47	46	44	46	45
	Midshaft	162	166	147	161	174	161	164	169	157	168
	HUMMXD	25	24	22	23	25	25	23	23	23	24
	HUMMWD	21	19	18	19	21	18	18	18	18	20
(L) Humerus											
	HUMXLN	322	330	293	320	345	324	326	337	315	330
	HUMBUE	54	52	50	52	54	54	51	50	49	52
	HUMEBR	64	63	61	64	70	70	61	64	64	58
	HUMHDD	50	48	45	45	50	48	45	44	46	47
	Midshaft	161	165	147	160	173	162	163	169	158	165
	HUMMXD	24	23	21	22	26	24	22	22	21	24
	HUMMWD	21	19	18	18	23	19	17	17	18	19
(R) Radius											
	RADXLN	253	260	229	260	274	252	254	264	240	256
	RADHDD	25	23	24	24	26	24	26	24	24	24
	Midshaft	127	130	115	130	137	126	127	132	120	128
	RADAPD	15	13	13	13	13	12	12	13	13	14
(L) Radius											
	RADXLN	253	261	230	259	271	250	257	261	238	252
	RADHDD	25	22	24	23	26	24	24	24	25	24
	Midshaft	127	131	115	130	135	125	129	131	120	126
	RADAPD	13	13	13	13	13	12	12	13	12	14
(R) Femur											
	FEMXLN	467	480	425	464	498	449	482	472	445	456
	FEMBLN	462	474	424	462	495	447	478	470	445	451
	FEMMAP	88	84	82	85	88	85	90	82	83	87
	FEMHDD	49	48	46	48	51	48	51	48	47	49
	Midshaft	234	240	213	232	249	225	241	236	223	228
	FEMMAP	34	31	25	35	33	33	29	32	31	35
	FEMMTV	31	25	27	29	28	30	28	28	27	27
	FEMCIR	100	87	82	99	99	99	90	96	90	98
(L) Femur											
	FEMXLN	464	483	429	468	498	451	486	471	449	460
	FEMBLN	460	479	427	466	496	450	480	469	447	457
	FEMMAP	88	84	81	85	88	85	90	82	84	90
	FEMHDD	48	48	46	49	52	48	50	46	47	49
	Midshaft	232	242	215	234	249	226	243	236	225	230
	FEMMAP	33	32	25	33	33	32	29	32	31	34
	FEMMTV	31	26	27	31	29	29	26	29	30	27
	FEMCIR	100	90	82	100	99	96	87	95	95	97
(R) Tibia											
	TIBXLN	396	391	355	390	427	378	391	403	362	381
	TIBPEB	82	74	78	81	82	80	85	76	76	81
	TIBDEB	51	45	47	51	51	51	50	51	50	49
	TIBNFX	43	32	33	40	36	36	33	40	26	39
	TIBNFT	30	25	25	23	26	25	24	25	25	26
	TIBCIR	115	91	92	100	98	97	90	102	96	100
(L) Tibia											
	TIBXLN	399	393	359	392	427	380	392	402	368	387
	TIBPEB	80	75	76	82	83	80	85	78	79	88
	TIBDEB	51	46	48	52	51	52	51	52	50	50
	TIBNFX	41	34	33	40	35	37	32	39	37	36
	TIBNFT	29	24	24	26	27	26	23	24	25	25
	TIBCIR	107	91	90	100	99	97	86	99	96	96

Vita

Lauren Ashley Garroway was born in Boynton Beach, Florida on December 23, 1986. She was raised in West Palm Beach and completed the International Baccalaureate program at Atlantic Community High School. Lauren attended the University of Florida, doubling majoring in Anthropology and Criminology and graduating Cum Laude with her B.A. in 2009. She went on to pursue her M.A. in Anthropology, with a concentration in Biological Anthropology, at the University of Tennessee. She currently resides in Knoxville, TN and plans to pursue a Ph.D. in Biological Anthropology.