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Morphological considerations of the human hyoid bone

Joanne Lorraine Devlin
University of Tennessee

To the Graduate Council:

I am submitting herewith a dissertation written by Joanne Lorraine Devlin entitled "Morphological considerations of the human hyoid bone." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

Murray K. Marks, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Morphological Considerations of the Human Hyoid Bone

A Dissertation
Presented for the
Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Joanne Lorraine Devlin
May 2002

Dedication

For the team.

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Abstract

This study combines the anthropological focus upon skeletal variation with the pathological interest in trauma to reveal the immense variation and complexity in laryngeal structures. Further, this study dispels the notion of a causal relationship between advancing age and fusion of the hyoid bone. Anthropological studies of hyoid anatomy are rare, primarily focusing upon correlating fusion with advancing age (see O'Halloran and Lundy, 1987) and secondly upon discerning aspects which contribute to hyoid fracture (see Pollanen et al., 1995; Pollanen and Chiasson, 1996; Pollanen and Ubelaker, 1997). These examinations fail to address the true morphological variability that characterizes the hyoid.

The hyoid structure is traditionally described in anatomical treatises as a "U" shaped bone of a consistent form, a form that develops and fuses with advancing age. However, a preliminary investigation (Bennett and Marks, 1998) demonstrated that often the juncture of the greater horns and the body remain unfused throughout adulthood. To date, standard anatomical texts refrain from acknowledging this variability, erroneously perpetuating the concept that the greater horns are nothing more than epiphyses of the hyoid body. Exploration into the range of skeletal variation inherent in the hyoid is crucial for interpretation of trauma, given that the fragility and location of the laryngeal structures render them especially vulnerable to traumatic injury.

Towards this end, the structure of the hyoid, as revealed by the extent of fusion and overall size measurements, was compared against recorded age, sex and ancestry. Hyoid specimens, (N=1814) maintained at the Department of Anthropology at The University of Tennessee, were examined for fusion and categorized as unfused, unilaterally fused, or bilaterally fused. Specimens that exhibit incomplete or partial fusion were subsequently scored on the pattern and degree of bony union between the body and the greater horns. Additionally, a series of measurements were performed to quantify overall size and shape. This research demonstrates patterns of fusion and will further illustrate the morphological variation that characterizes this skeletal structure.

Osteologists and anatomists must recognize the true variability of this structure, specifically by exploring the presumed relationship between advanced age and fusion, and further by developing an awareness of the degree of morphological variation which characterizes the hyoid bone. This study demonstrates the structural nuances that characterize the hyoid bone and subsequently generates information to competently and precisely interpret neck trauma.

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Chapter I

Introduction

The hyoid is comprised of several distinct skeletal components; the body and pairs of greater and lesser horns. However, throughout the scientific literature it is most often described and depicted as a single fused element (see for example, Jackson, 1914; Schaffer, 1953; Hiatt and Gartner, 2001). Commonly presented as "horseshoe shaped or U-shaped or sometimes as υ-shaped" (Papadopoulos et al. 1989:249), the hyoid is nearly always described as a symmetrical structure. Papadopoulos and coworkers found that asymmetry and anisometry occur in approximately half of the population noting that "the classical forms of the conventional descriptions are not the most frequent" (1989:256). In addition, they recognize that upwards of five shapes characterize human hyoids, noting that this is not mentioned in the literature.

Anatomical treatises perpetuate the hyoid as a single bone of a consistent form that develops and fuses with advancing age (see for example, Johnson and Moore, 1989; Jackson, 1914). Gray's Anatomy describes the hyoid in this same manner.

> "In early life they (the lateral surfaces) are connected to the cornua by cartliagenous surfaces, and held together by ligaments and occasionally a synovial membrane is found between them" yet after "middle life are joined to the greater cornua" (Pick and Howden 1977:23).

Similarly, a standard osteology text claims " the greater horns take a long time to fuse to the body and in fact remain separate in rare cases" (Steele and Bramblet 1988:52). A recently published clinical anatomy text further supports this view, noting that the greater horns are "attached by a cartilagenous connection earlier in life. The cartilage ossifies in middle-aged individuals" (Hiatt and Gartner, 2001:82).

These publications promote the concept that the hyoid's greater horns, in effect, function as epiphyses of the body. This interpretation, therefore, biases the potential anatomical, pathological, and clinical evidence that can be gleaned through examination of the components of the hyoid bone. Although the literature produced within these disciplines contains a wide variety of references to hyoid conditions, these reports suffer from a failure to recognize the variability that characterizes the human hyoid bone. Clearly, a thorough appreciation of the range of variation inherent in this structure is crucial for the accurate assessment of the hyoid in both antemortem and postmortem situations.

The fragility and location of the laryngeal structures which constitute the anterior neck, render them especially vulnerable to traumatic injury. Fractures of the laryngeal structures are frequently associated with manual and ligature strangulation. The external manifestation of such trauma is not always evident (Spitz, 1980). Often, assessment of the condition of the hyoid bone components may merely involve palpation of the laryngeal structures. Hence the implications of an accurate understanding of hyoid morphology at autopsy is great. Postmortem examinations must incorporate a thorough awareness of the morphology that characterizes the hyoid bone, in particular by reflecting on the presumed relationship between advanced age and fusion of the elements. Osteologists and anatomists must further consider the true variability of this structure by developing an appreciation for the degree of morphological variation that characterizes this delicate structure. Unfortunately, such interpretations are plagued by the unquestioned acceptance that the skeletal elements of the hyoid bone unite with advancing age. Understandably, this erroneous assumption regarding the development of the laryngeal skeleton is frequently incorporated into forensic interpretations.

Research has demonstrated that the cartilagenous components of the human larynges exhibit a high degree of variability (see for example, Maue and Dickson, 1971). Overall size differences have been noted for the laryngeal cartilages of males compared to females. Maue and Dickson, (1971) do note that a high degree of variation characterize structural attributes of specific laryngeal components. Further that these structures demonstrate a high degree of within group (i.e., gender) variability (Maue and Dickson, 1971). Similarly an appreciation of the potential morphological variability which characterizes the hyoid bone must be generated and is crucial in clinical and pathological assessments. It is not the aim of this study to suggest that union does not occur. Moreover, it is to propose that union should not be unequivocally associated with advancing age synonymous with overall skeletal maturation. Nonunion of the components of the hyoid bone in individuals of middle and advanced age must be considered during forensic examination of the components of the larynx.

The anthropological value of the human hyoid, as proposed long ago by Wortman (1889), continues to be unrealized. Though he suggested the hyoid bone holds the potential to distinguish between population groups, he further noted that this bone has not received the appropriate investigative attention from anthropologists in comparison to anatomists. Particularly insightful, this commentary may in part explain the absence of appreciation for morphological variation of the structure. Wortman notes that anatomists

> "seem to be pretty well agreed in assigning the middle period of life as the time which the greater cornua of the hyoid unite or coossify with the median piece or body, and a much later period for the bony union of the lesser cornua" (1889:81).

Further, and of particular interest, he states that,

> "no less an authority than Meckel is responsible for the statement that the five pieces rarely unite and should be considered as so many separate bones" (1889:81).

He further professes that others accept Meckel's interpretation and subsequently proposes that fusion should be considered a pathological condition (Wortman, 1889). It has also been suggested that union of components of the hyoid bone may have one of two developmental tendencies. Koebke suggests that the occurrence of an osseous union between the body and the greater horns or the existence of a joint at this location may be determined during fetal development.

> "...two divergent developmental tendencies can be taken into consideration. In some cases a synovial joint is formed, other hyoid bones show characteristics indicating a possible fusion of the body and the greater horns" (1978:286).

However, absent from this location are structures that would warrant classification of the juncture of the hyoid body and the greater horns as a synovial joint.

Survey of the hyoid bone must delve deeper than merely suggesting that advanced age can or cannot not be equated with fusion. The developmental and dimorphic attributes of the hyoid bone must be thoroughly explored. In particular, consideration must be given to whether there are patterns to fusion and whether such patterns can be correlated with age, ancestry and or sex. Further, the evolutionary and functional significance of the hyoid bone must be addressed as such may illuminate and explain potential morphological features. In addition, a thorough exploration must incorporate a substantial sample size which represents the population in age range and ancestry.

Project Aims

The goal of this research is to objectively investigate the structure of the human hyoid bone. Analysis of the sample will follow the techniques established from previous research (see Chapter III). Both metric and visual data will be generated to accurately assess the degree of morphological variability which characterizes human hyoid bones from birth to maturity. This study will provide data that illuminates developmental and degenerative aspects of the hyoid. Such will enable more accurate pathological, anthropological, anatomical, and clinical examinations of the bone. This data will provide an objective means to interpret neck trauma, clinical conditions, and morphological attributes of the hyoid bone with greater precision. Specific considerations will address:

1. Does overall size and shape, as depicted through a suite of measurements, correlate with age, sex and/or ancestry?
2. Are certain structural characters associated with sex or ancestry?
3. Are there correlations between advancing age and the development of morphological features?
4. Can fusion between components of the hyoid be correlated to age, sex and/or ancestry?
5. Is there a structural pattern to fusion between the body and the greater horns of the hyoid bone?

6. What are the implications of this study for forensic pathologists, forensic anthropologists and clinicians?

Chapter II

Laryngeal Anatomy

The Laryngeal Complex

The larynx, essentially a cartilaginous cylinder, surrounds and protects the glottis and functions as a chamber for the movement of air between the nasal and oral pharynx and the trachea. Situated in the anterior neck between the third and seventh cervical vertebrae, the adult laryngeal complex is comprised of several cartilaginous components and a skeletal structure; the hyoid bone (see Figure 2.1). The superior most component, the hyoid bone, is comprised of a body and paired greater and lesser cornua, and provides an anchor points for numerous muscles. The cricoid cartilage delineates the inferior boundary of the larynx and further functions to support the trachea (see for example Hiatt and Gartner, 2001; Liebgott, 1986).

The adult larynx consists of three large cartilages; the epiglottis, the thyroid and the cricoid. Three smaller paired cartilages crucial for the production of speech sounds, are the arytenoids, the corniculates, and the cuneiforms. In addition, a pair of accesory cartilages, the triticeals, complete the laryngeal cartilage structures. The thyroid, cricioid and arytenoids are comprised of hyaline cartilage whereas the epiglottis, the corniculates, and the cuneiforms are elastic

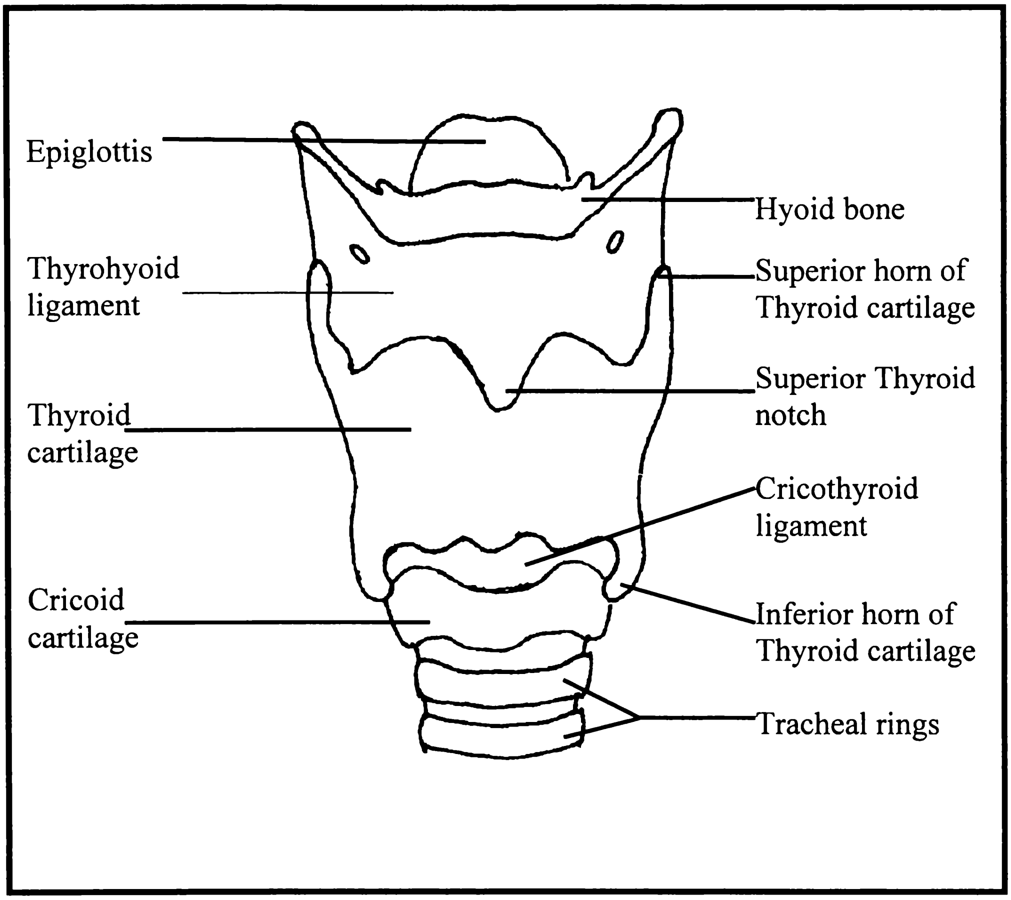

Figure 2.1 Anterior view of the laryngeal complex depicting the hyoid bone and cartilages of the larynx with associated membranes. Adapted from Netter, 1989.

cartilage. A network of ligaments and muscles maintain the functional integrity of the laryngeal complex.

Cartilaginous Laryngeal structures

The epiglottis, a flat-blade shaped structure that automatically blocks the entrance to the trachea during swallowing, is located superior to the thyroid and is protected on its posterior surface by the hyoid (see Figure 2.2). The thyrohyoid, or hyothyroid, membrane lies between the anterior epiglottis and the posterior hyoid surfaces (Schaffer, 1953). Tapered at the inferior border the epiglottis is marked by a tubercle, the petiole, which serves as the attachment site for the thyroepiglotic ligament. This connects to the inferior aspect of the dorsal surface of the thyroid (Jackson, 1914). The shield-shaped and slightly conical thyroid cartilage is comprised of two quadrilateral shaped laminae. The anterior surface is marked by a vertical ridge, the laryngeal prominence, produced by the inferior fusion of the laminae along the midline (Moore, 1992). The angle of union of the laminae is more acute (on average 60^{o}) in males compared to (approximately 90^{o}) in females (Grant, 1972). The anteroposterior dimension is greater in males than in females (Maue and Dickson, 1971). The anterior surface is further characterized by a pair of laterally located oblique lines, attachment sites for infrahyoid muscles. The supero-anterior surface is noticeably marked by a deep incisure, the superior thyroid notch. Both the superior and inferior aspects of the posteriolateral thyroid are characterized by small tubular projections, greater, or

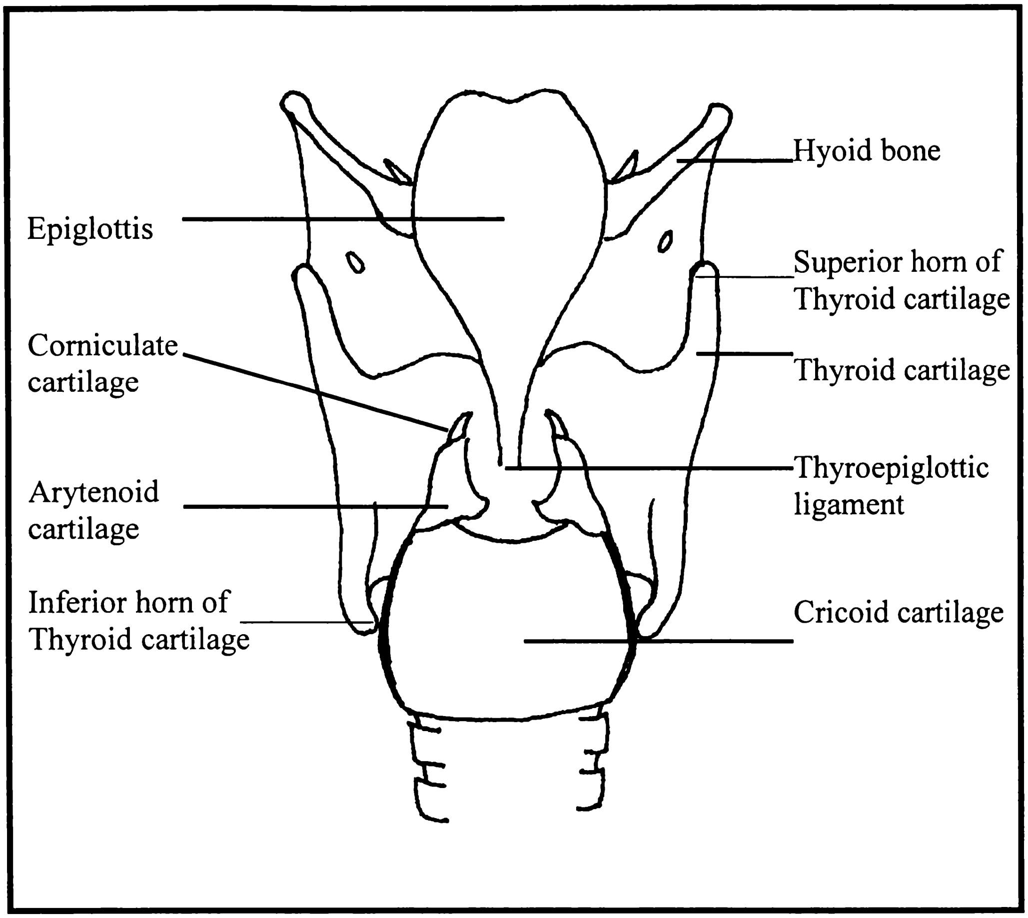

Figure 2.2 Posterior view of the laryngeal structures. Adapted from Netter, 1989.

superior, and lesser, or inferior, horns. Though all project slightly posteriorly, the greater horns are longer and the distance between the tips of the superior and inferior horns is significantly greater for males than for females (Maue and Dickson, 1971; Garrison and Hast, 1993). Additionally, among males the distance between the span of the superior horns is significantly greater than the span of the inferior horns (Maue and Dickson, 1971).

The thyrohyoid ligament, an extrinsic ligament, attaches the anterior aspect of the hyoid bone to the thyroid cartilage. The lateral portions of the hyoid bone are bound to the thyroid cartilage by the thyrohyoid membrane. Both supero-lateral zones of this membrane are permeated by symmetrical foramina through which the internal laryngeal nerve and the superior laryngeal artery and vein pass. A pair of accessory cartilages, the triticeals, are located within the thyrohyoid membrane, superior to the superior horns of the thyroid cartilage (Jackson, 1914). Embedded within the membrane, these cartilages are derived from the cartilage which connects the hyoid body and the lamina of the thyroid cartilage during the embryonic period (Porrath, 1969).

Located inferior to the thyroid is the ring-shaped cricoid cartilage. Narrow on its anterior surface, at the cricoid arch, the cricoid cartilage provides stablility for the inferiorly situated tracheal cartilages and gives rise to muscles of respiration. The broader posterior aspect, the cricoid lamina, forms the posterior border of the laryngeal cavity (Jackson, 1914). The lateral aspects of the cricoid cartilage are bound to the inferiorly situated trachea by the cricotracheal ligaments. The superior surface of the cricoid is marked by the thyrocricoid facets; the site of articulation with the thyroid (Maue and Dickson, 1971). Accessory bands, the median cricothyroid ligaments, maintain the articulation between the inferior horns of the thyroid and the lateral cricoid at the cricothyroid articular capsule. Rotary movement and slight forward and backward motion is permitted at this joint (Jackson, 1914). Aspects of the cricoid cartilage exhibit statistically significant size differences between male and females (Maue and Dickson, 1971).

The cartilage components of these laryngeal structures provide attachment sites for numerous extrinsic muscles which are involved in the stabilization of the larynx and transmission of material through the pharynx. The inferior constrictor, a pharyngeal constrictor originates on the lateral aspects of the thyroid and cricoid cartilages and functions to propel food particles into the esophagus. Two laryngeal elevators, the palatopharyngeus and the salpingopharyngeus, insert on the thyroid cartilage. In conjunction with the thyrohyoid, geniohyoid, stylohyoid, and hyoglossal muscles (see below) the laryngeal elevators elevate the larynx (Dickson and Maue, 1970).

Located superior to the cricoid within the protective cavity of the thyroid cartilage are the three pairs of smaller cartilages. A network of ligaments; intrinsic, extrinsic and ventricular and vocal, bind the smaller cartilage components together and are involved in sound production. The largest of these is the triangular-shaped arytenoid cartilages, from the Greek arytaina, ladle shaped (Garrison and Hast, 1993). The most mobile of all laryngeal cartilages, the arytenoids, unite with the superior cricoid lamina at the cricoarytenoid articulation, a loose capsular joint (Jackson, 1914). The cricoarytenoid ligaments maintain this loose articulation and enable a minimal, though broad range of movement (see Netter, 1989). The lateral aspect of each cartilage joins with the epiglottis via the aryepiglottic fold. The anterior angle of the arytenoid cartilage, the vocal process, serves as the attachment site for bands of elastic tissue, the vocal ligaments. Attached to the dorsal surface of the thyroid and the cricoid, the vocal ligaments, are enveloped in folds of epithelium called vocal folds. These structures are referred to as true vocal cords as the passing of air against the vibrating vocal folds produces sound waves. Located superior to the vocal folds are the inelastic ventricular folds, or the false vocal cords, which function to protect the vocal folds (Hiatt and Gartner, 2001; Liebgott, 1986). Movement of the arytenoid cartilages alters the tension within the vocal ligaments which subsequently influences the pitch of sound produced. Partially attributable to the role of the arytenoid cartilages in sound production, sex differences have been noted for these structures. Busuttil et al (1981) suggest the size of the arytenoid cartilages is correlated with both the sex of the individual and also standing height, with males generally being longer.

It has been suggested that the arytenoid cartilages are phylogenetically the oldest part of the human larynx, likely having evolved from the anterior laryngeal cartilage, a fibrocartilaginous plate found in front of the laryngeal eminence in amphibians (Wind, 1970). Curtis and coworkers (1985) found that this structure calcifies and ossifies following a radiological assessment of 53-93 year olds of which 90% displayed calcification and or ossification.

The medially projecting apices of the arytenoid cartilage and the small conical corniculate cartilages join at the arycorniculate synchondrosis by connective tissue. Involved in opening and closing the glottis, the posteromedially angled horn shaped corniculate cartilages are occasionally continuous with the arytenoids (Jackson, 1914). The small rod like cuneiform cartilages are situated anterior to the corniculate cartilages within the aryepiglottic fold providing the structural integrity to the larynx.

The Hyoid Bone

The hyoid bone, from the Greek "voides" or "ypsiloides" (Papadopoulos et al., 1989), is situated high in the anterior neck between the chin and the thyroid cartilage, delineating the superior aspect of the larynx. The hyoid bone, os hyoideum or os linguae, supports the tongue and provides attachment sites for numerous muscles which, in conjunction with the cartilaginous components of the larynx, aid in facilitating processes of mastication, deglutition and phonation. Suspended from the styloid processes of the temporal bones by the stylohyoid ligaments, the hyoid bone is comprised of five segments: a single body, and pairs of greater and lesser horns, or cornua (Johnson and Moore, 1989, Hiatt and Gartner, 2001) (see Figure 2.3). Lacking bony articulations, the components of

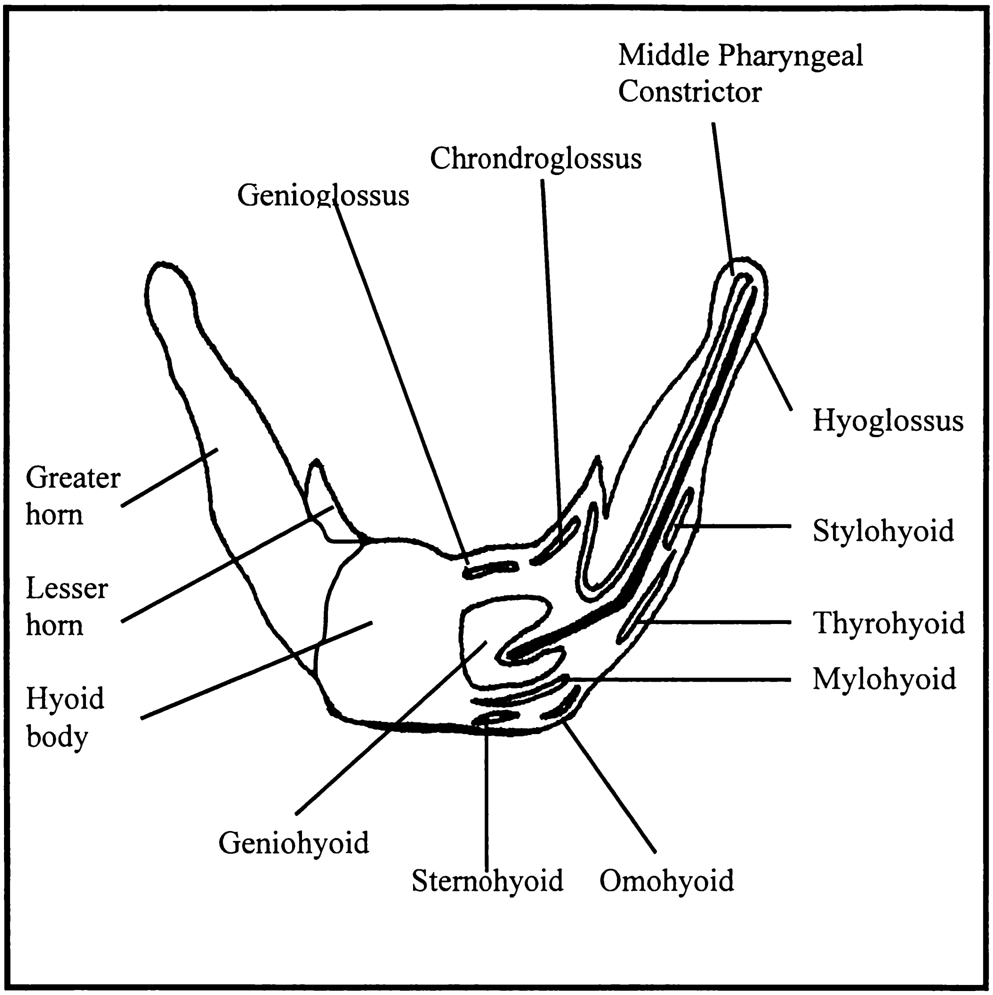

Figure 2.3 The hyoid bone. Muscles and attachment sites are depicted on the left side of the specimen. Adapted from Jackson (1914) and Stepovich (1965).

the hyoid bone are maintained in position by a series of muscles which further function to manipulate the tongue, mandible, pharynx and larynx (Lykaki et al., 1989). A network of muscle pairs, the stylohyoid, geniohyoid, sternohyoid, and the digastric muscles radiate in a triangular fashion from the hyoid body and are primarily responsible for the integral role the hyoid plays in these system functions (Van der Graaff et al., 1984) (see Figure 2.4).

The body, comprising the central portion of the hyoid bone, is quadrilateral in shape, concave posteriorly and convex anteriorly (Johnson and Moore, 1989; Parsons, 1909). The anterior surface is prominently marked by a horizontal ridge which bisects the body into superior and inferior halves. A midline vertical ridge further divides the anterior surface into quarters associated with muscle attachment. The superior border is marked by a sagitally oriented bony prominence, the glosso-hyal ridge. This landmark, has been noted by some as a likely vestige of a highly developed process in non-human species (Jackson, 1914; Schaffer, 1953). The inferior aspect of the body is thickened, providing for attachment of the sternohyoid and mylohyoid muscles anteriorly and the thyrohyoid membrane across the inferior margin.

The prominent posteriosuperiorly oriented projections; the greater horns, or greater cornua, articulate with the lateral margins of the body. Slightly flattened across the superior aspect, the greater horns, are thickest adjacent to the body and terminate in rounded tubercles (Parsons, 1909). The greater horns are rough laterally, which Parsons (1909) attributes to muscular attachment and

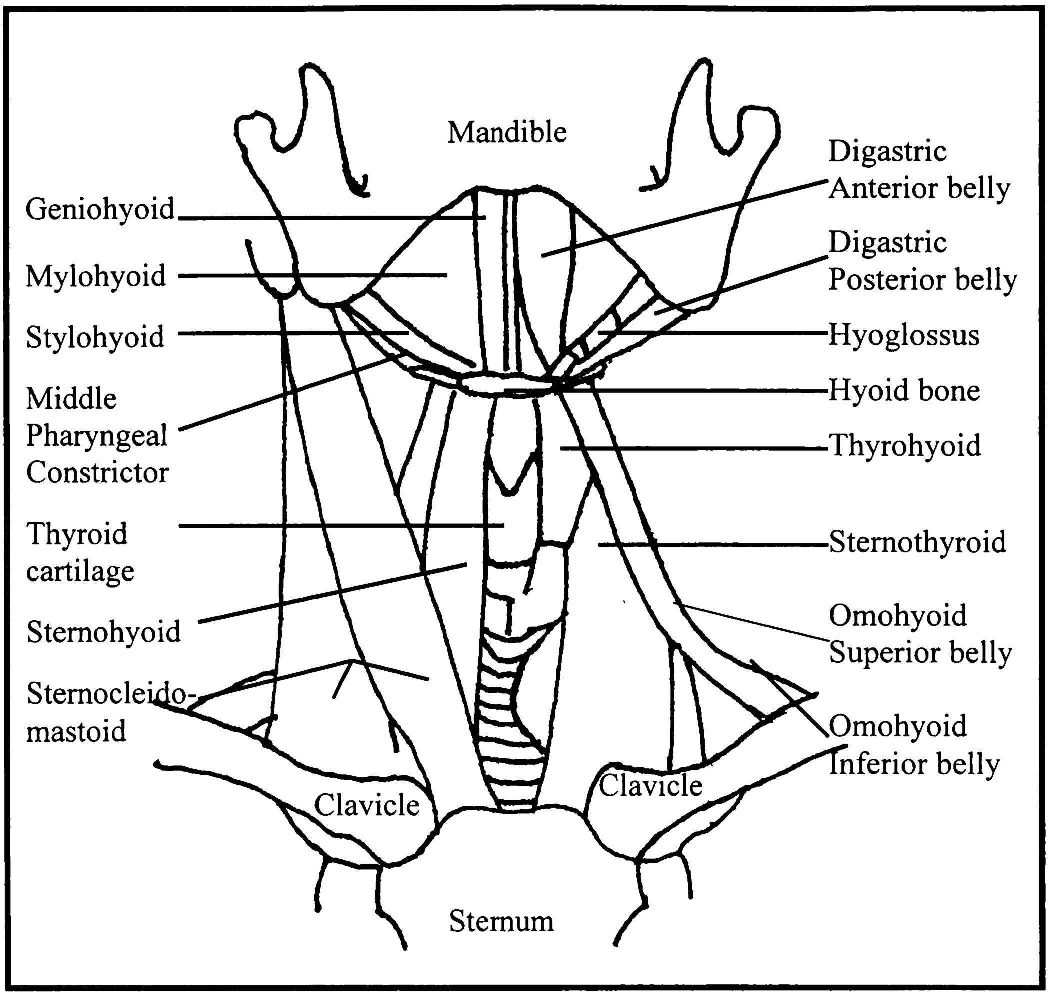

Figure 2.4 Anterior neck view depicting hyoid bone and associated musculature.

activity, and everted. Scheuer and Black (2000) regard the latter characteristic as being more prominent among males. The juncture of the body and the greater horns is associated, most frequently on the superior margin, by the presence of the lesser horns, or lesser cornua (Johnson and Moore, 1989). These small vertically oriented conical projections articulate with the hyoid via a synovial joint and often remain cartilaginous in the adult. It has been noted, that the lesser horns connect with the body at the inferior border (Jelisiejew et al., 1968). However, it has been suggested that the lesser horns rarely ankylose with the body, being more likely to fuse with the greater horns (Jackson, 1914). Koebke (1978) attests that a bony union between the lesser horns and the hyoid is rare, though occasionally the lesser horns will fuse with the greater horns.

Hyoid Musculature

A network of muscles permit movement and momentary fixation of the components of the hyoid bone. This is critical for normal performance of the tongue, mandible, pharynx and larynx (Dubrul, 1977). Eleven pairs of muscles support the hyoid apparatus. Four of these, the geniohyoid, mylohyoid, stylohyoid and digastric muscle pairs are classified as suprahyoid muscles and act to elevate the larynx and manipulate the mandible and the floor of the mouth. Infrahyoid muscle pairs include the sternohyoid, thyrohyoid and omohyoid, which depress or elevate the hyoid or thyroid cartilages of the larynx (Hiatt and Gartner, 2001; Moore, 1992). The hyoglossus is paired extrinsic tongue muscle that facilitate gross movements of the tongue. The middle constrictor muscle is a pharyngeal constrictor.

The anterior surface of the hyoid body is most prominently marked by the insertion point of the geniohyoid muscle (see Figure 2.3). The geniohyoid muscle originates on the inferior mental spine of the dorsal mandibular symphysis , runs inferiorly and inserts lateral to the vertical midline of the hyoid body. The insertion site comprises approximately half of the anterior surface and provides for anterosuperior movement of the hyoid bone, expansion of the pharynx and shortening of the floor of the mouth. Situated inferior to the insertion site of the geniohyoid muscle is the insertion site of the mylohyoid muscle, a broad flat muscle that originates on the mylohyoid line of the mandible. Forming the floor of the mouth, contraction of the mylohyoid muscle elevates the hyoid bone and the floor of the mouth during swallowing and speaking.

The stylohyoid muscle, which originates on the styloid process of the temporal bone as the stylohyoid ligament, inserts on the inferior aspect of the anterior portion of the greater horn. The inferior aspect of the stylohyoid ligament attaches on the lesser horns (Scheuer and Black, 2000). In addition to its suspensory role, the most superficial of the suprahyoid muscles, the stylohyoid muscle elevates and retracts the hyoid generating elongation of the floor of the mouth. The stylohyoid muscle overlays the posterior belly of the digastric muscle. The flat triangular anterior belly originates on the inferior anterior surface of the mandible at the digastric fossa and overlays the oblique course of the mylohyoid muscle. The posterior belly originates at the digastric notch on the medial surface of the mastoid process of the temporal bone. The confluence of the two bellies occurs at the point of attachment, via a fascia loop, on the superodorsal surfaces of the greater horn and the hyoid body. The intermediate tendon of the digastric muscle attaches to the lesser horn (Scheuer and Black, 2000). The digastric muscle functions to depress the mandible and raise and steady the hyoid bone during swallowing and speaking.

The infrahyoid muscles are thin strap-like muscles which originate on structures inferior to the hyoid. The sternohyoid muscle inserts on the inferior aspect of the anterior surface of the body originating on the oblique line of the thyroid cartilage. Situated just lateral to this is the insertion site for the superior belly of the omohyoid muscle. The sternohyoid muscle originates on the manubrium and the medial portion of the clavicle and acts to depress an elevated hyoid. The long thin omohyoid muscle originates on the superior border of the scapula at the suprascapular notch and functions to retract and depress the hyoid. The short thyrohyoid muscle, which lies deep to the omohyoid, inserts along the inferior aspect of the body and the greater horn. Originating on the oblique line of the thyroid cartilage this muscle depresses the hyoid bone and elevates the larynx (Auger and Lee, 1999).

The thin broad hyoglossus is an extrinsic tongue muscle that originates along the length of the greater horn and the posteriolateral aspect of the hyoid body. Under contraction, the hyoglossus, which inserts on the sides of the tongue, depresses the lateral aspects of the tongue. The genioglossus muscle originates at the mental spines of the mandible and provides for depression and protraction of the tongue. The fibrous components of this muscle constitute the majority of the tongue and additionally radiate inferiorly to insert on the superoanterior margin of the hyoid body. Lateral to this site, at the base of the lesser horns, is the origination point of the small chondroglossus muscle, which joins longitudinal muscles of the tongue (Jackson, 1914).

The middle constrictor muscle is a pharyngeal constrictor that originates along the length of the greater horn continuing to the base of the lesser horn (Scheuer and Black, 2000). This attachment site is superomedial to the origination site of the hyoglossus muscle. The middle constrictor, which lies deep to the hyoglossus, constricts the pharynx and in conjunction with the superior and inferior constrictors, aids in the downward movement of food through the esophagus.

Laryngeal Development

A thorough understanding of the intrauterine development and the subsequent post-natal maturation of the laryngeal structures are crucial to appreciate the function of the laryngeal complex. The earliest embryonic recognition of the larynges is evidenced by the separation of the digestive and respiratory tracts (Wind, 1970) (see Figure 2.5). This event is recognized by the appearance of a median groove, the laryngo-tracheal groove, in the embryo during

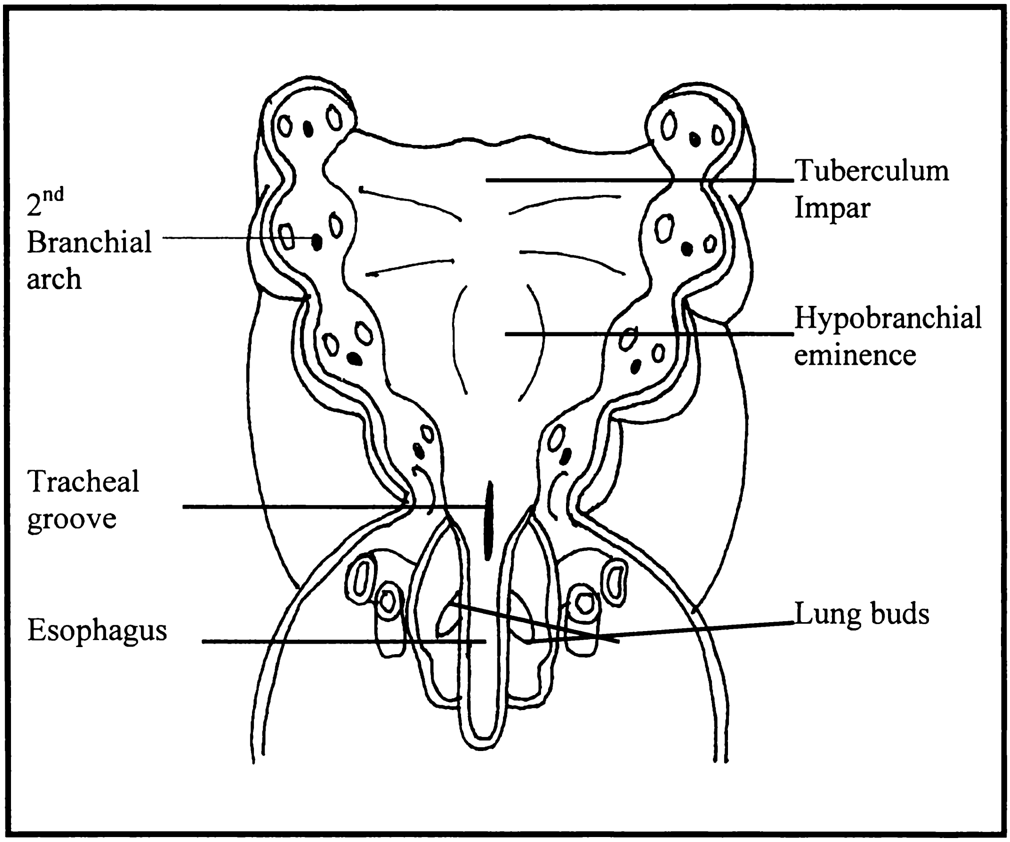

Figure 2.5 Anterior view of longitudinal section of a three-week-old embryo depicting precursors of the superiorly located laryngeal structures separated by the tracheal groove from the respiratory and digestive structures. Adapted from Wind 1970.

the third week of intrauterine growth, or the first week of embryonic development (Wind, 1970). The remaining period of embryonic growth is characterized by the rapid development of all components of the larynx. During the subsequent developmental stage, the fetal period, maturation and differentiation of the laryngeal elements occur. Ossification of the skeletal structures begins during the neonatal period and proceeds throughout childhood. The childhood and juvenile periods are characterized by the continuing maturation of all cartilage and skeletal components. Maturation associated with puberty influences development of the human larynges. Morphological variation and sexual dimorphism are recognized in several structures which comprise the adult larynges.

Embryonic Growth

The embryonic phase of human growth, the third through the eighth week of prenatal development, is often referred to as the period of organogenesis given that the rudiments of nearly all major organ systems appear during this stage. At this time, the C-shaped embryo is characterized by the existence of a massive central neural tube, a notochord and a pharyngeal system (Carlson, 1999). Structures and components of the head, face, and neck derive from the pharyngeal part of the foregut (Carlson, 1999). The foregut first appears at approximately 19 days post conception. Formation of the larynx occurs during the following two weeks developing into a recognizable structure approximately 33 days following conception (O'Rahilly and Tucker, 1973).

Adult structures of the head and neck region derive from a series of paired swellings, which appear during the fourth week of embryonic development. By the fifth week of intrauterine maturation this region is comprised of six lateral, mesenchymal elevations that extend ventrally around the developing pharynx (Orahilly and Tucker, 1973). Referred to as pharyngeal (or branchial) arches and identified by numbers one through six, craniocaudal sequence, each arch consists of a precartilaginous mesenchymal core coated with endoderm. The last two are rudimentary and often the fifth is absent (Scheuer and Black, 2000). During early development, neural crest cells surround the core. These cells migrate into each arch and give rise to muscles, skeletal and connective tissues (England, 1990). Each arch is innervated by a cranial nerve and supplied by a branch of the aortic artery that will continue to supply the mature derivatives (England, 1990).

The pharyngeal arches are separated by four clefts. These lateral expansions of the developing pharyngeal cavity, which intervene between the arches, form external and internal grooves, referred to as clefts and pouches, respectively (Orahilly and Tucker, 1973; Scheuer and Black, 2000) (see Figure 2.6). During this phase of embryonic development the physical resemblance to the gill respiratory structure of adult fish is often noted (see for example England, 1990). The arches are analogous to the gills in lower vertebrates while the grooves are comparable to the branchial slits (Jackson, 1914). Although these structures are in fact similar among reptiles, birds, mammals and fish embryos, it

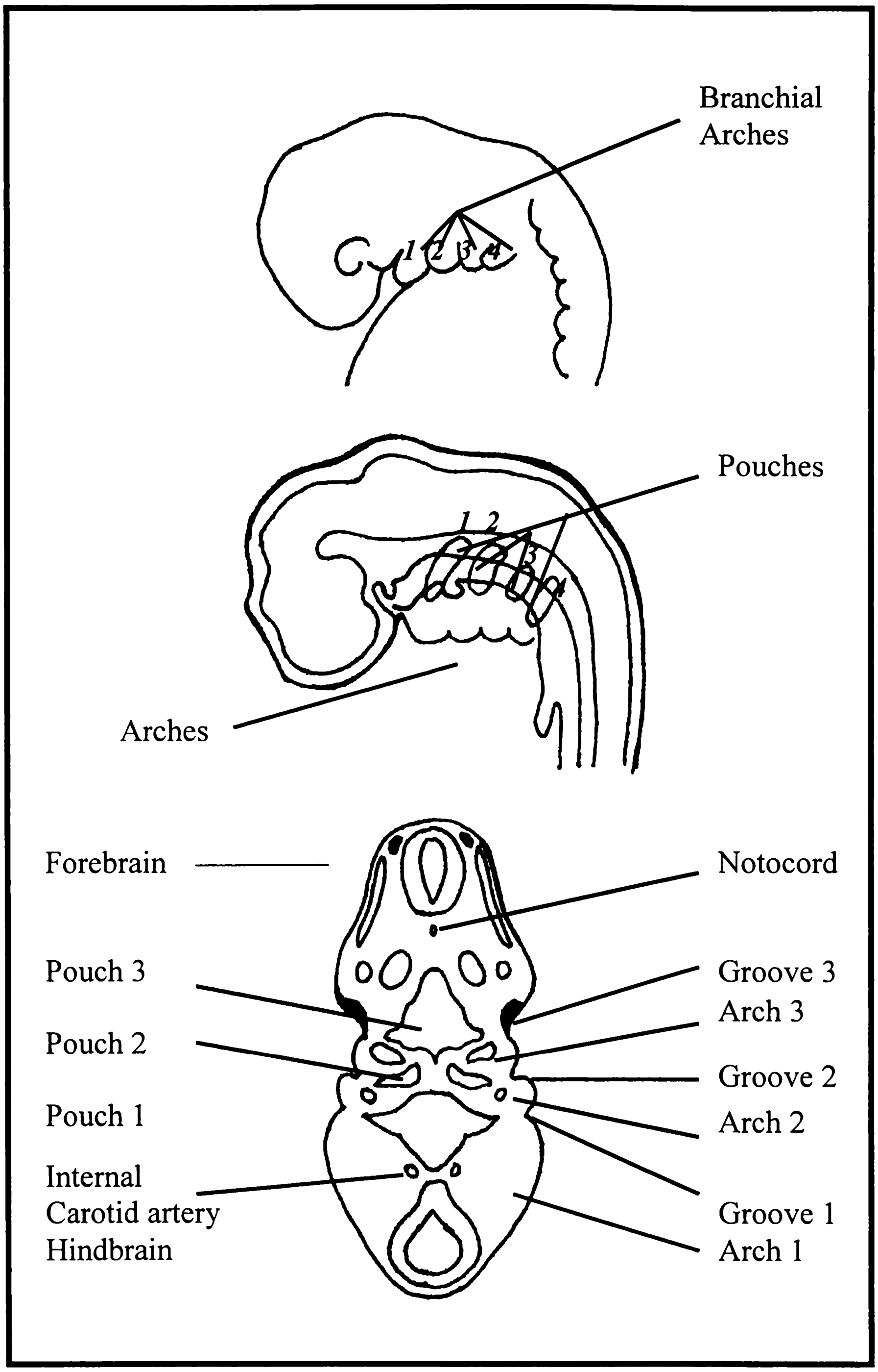

Figure 2.6 Depiction of the pharyngeal structures in an embryo at five weeks. Top to bottom: surface, sagittal and cross sectional views. Adapted from Carlson 1999.

is only the latter that maintain these visceral arch constructs while in other phyla they are modified into other structures (Harrison, 1995). Structures of the pharynx and larynx, primarily arise from the first four of the pharyngeal arches, given that the last two are rudimentary and occasionally the fifth is absent or short-lived (Hiatt and Gartner, 2001; Sperber, 2001; Scheuer and Black, 2000). Additionally, several features of the head and neck are derived from the pharyngeal grooves and pouches (see Figure 2.7).

The first arch, the mandibular arch, gives rise to the structures of the lower face and related muscles of mastication. The cartilaginous component of the first branchial arch, Meckel's cartilage, forms the primary component of the mandible and also gives rise to the malleus and incus bones of the middle ear. In addition, the anterior belly of the digastric muscle and the mylohyoid muscle are derived from the first pharyngeal arch (Sperber, 2001; Carlson, 1999). The mandibular branch of the trigeminal nerve innervates these structures (Sadler, 1995). The first pharyngeal external groove, caudal to the first arch, deepens to form the external auditory meatus (Jackson, 1914). The first internal groove, or pouch, is transformed into the tympanic cavity and the eustachian tube (Carlson, 1999). Components of the first arch begin to undergo ossification during the late embryonic period; at approximately 7 weeks post conception. The mandible (lateral portions of first arch cartilage) evidences onset of ossification at 44 days. Ossification of the anterior process of the malleus, the lateral most bone of the middle ear, begins approximately two days later (O'Rahilly and Gardner, 1972).

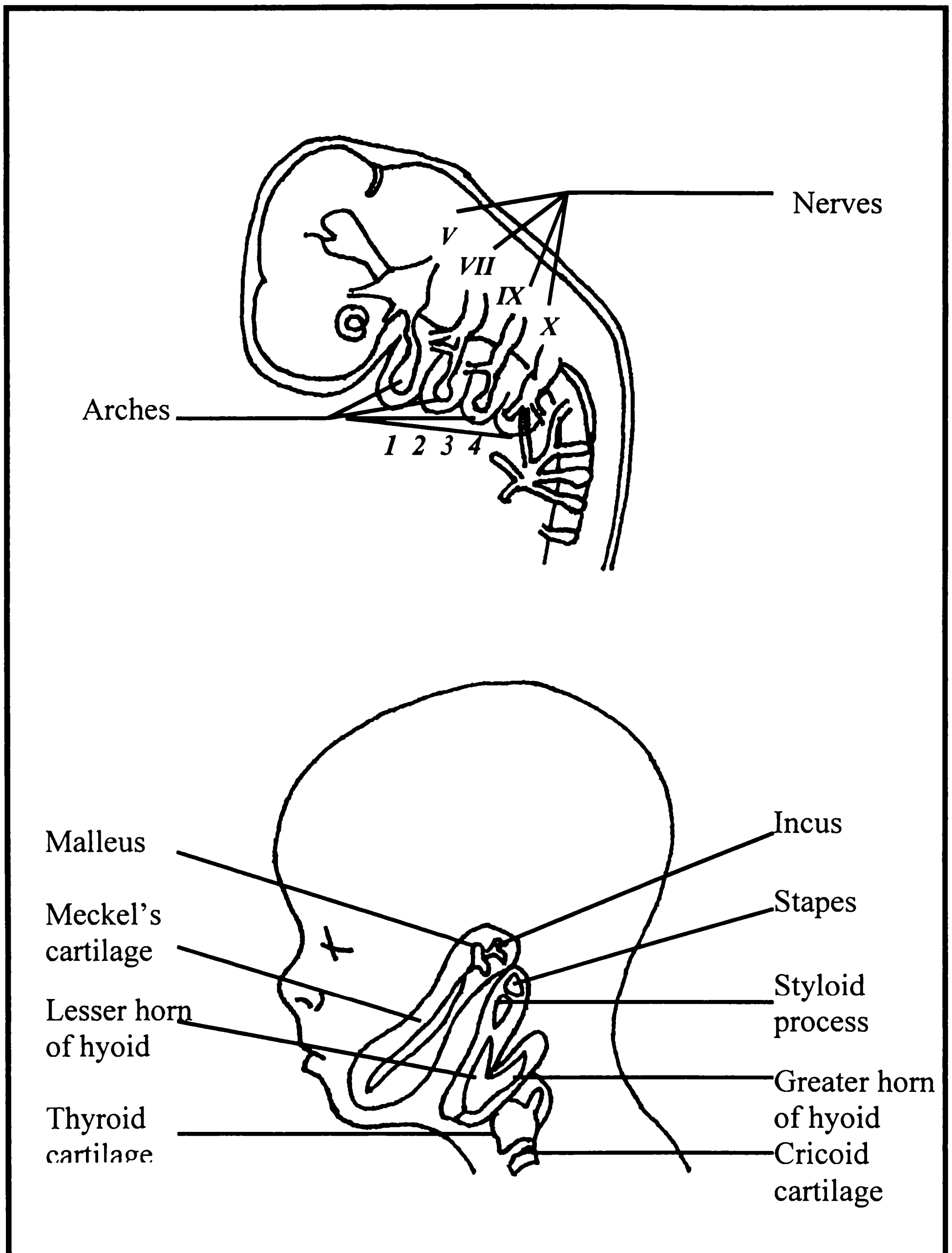

Figure 2.7 Pharyngeal (branchial) arch system depicting skeletal, neural, and cartilagenous derivatives. Sagittal sections at 6 weeks (above) and at birth. Adapted from Carlson 1999.

Embryologically, the hyoid and associated structures arise from the second and third branchial arches. The second arch, the hyoid arch, contributes to superior aspects of the hyoid bone and related structures (Hiatt and Gartner, 2001). The dorsal aspect of the second arch cartilage, Reichert's cartilage, gives rise to the lesser horns of the hyoid and the upper (superior) portion of the body (Sadler, 1995). The styloid processes of the temporal bone and the stapes, the third and medial most ear ossicle, are derived from the ventral section of the second pharyngeal arch. The adjacent section gives rise to the stylohyoid muscle and the posterior belly of the digastric, in addition to muscles of facial expression (Hiatt and Gartner, 2001; Carlson, 1999). The facial nerve innervates the musculature of the second arch (Sadler, 1995). Alternatively, it has been suggested that portions of the malleus and incus bones derive from the dorsal aspect of the second arch (Carlson, 1999).

The ventral portion of the third visceral arch cartilage, the thyroid arch, gives rise to inferior aspect of the hyoid body and the lateral aspects give rise to the greater horns (Sadler, 1995). Koebke (1978) proposes that in certain cases the ventral aspect of the third arch may be solely responsible for the development of the hyoid body, whereas in other individuals, the hyoid body may arise from the copula of the second and third arches. The musculature of the third arch, the stylopharyngeus, is innervated by the glossopharyngeal nerve (Sadler, 1995).

The grooves and pouches associated with the second and third arches give rise to several laryngeal structures. The caudal growth of the second arch envelopes the third and fourth arches and isolates the second, third and fourth clefts (Sadler, 1995). This developmental merger results in the formation of a depression, the cervical sinus, which appears to be absorbed and eventually disappears (Carlson, 1999). The tonsils are derived from the second pharyngeal pouch, while the third and fourth internal grooves give rise to the thymus gland and parathyroid glands, respectively (Carlson, 1999).

Primary cartilages and muscles of the larynx, with the exception of the epiglottis, are formed from the fusion of the fourth and sixth arches. The epiglottis develops from a round swelling located between the third and fourth arches, the hypobranchial (hypopharyngeal) eminence (see Figure 2.5). Two inferiorally located swellings, the lateral masses or arytenoid swellings, give rise to the arytenoid cartilages (Wind, 1970). These features are recognizable at approximately 32 days post conception (O'Rahilly and Tucker, 1973). The interarytenoid, aryepiglottic, cricoarytenoid, and crycothyroid muscles are the first laryngeal muscles to appear, doing so early in the sixth week of embryonic development (Hast, 1972). The superior laryngeal and recurrent laryngeal branches of the vagus nerve (cranial nerve X), innervate the musculature associated with these structures (Sadler, 1995).

The structures of the laryngeal skeleton are not recognizable until approximately the seventh week of embryonic development at which point the thyroid, cricoid, arytenoids and hyoid appear as rudimentary pre-cartilaginous tissues (Wind, 1970) (see Figure 2.8). At this level of embryonic development,

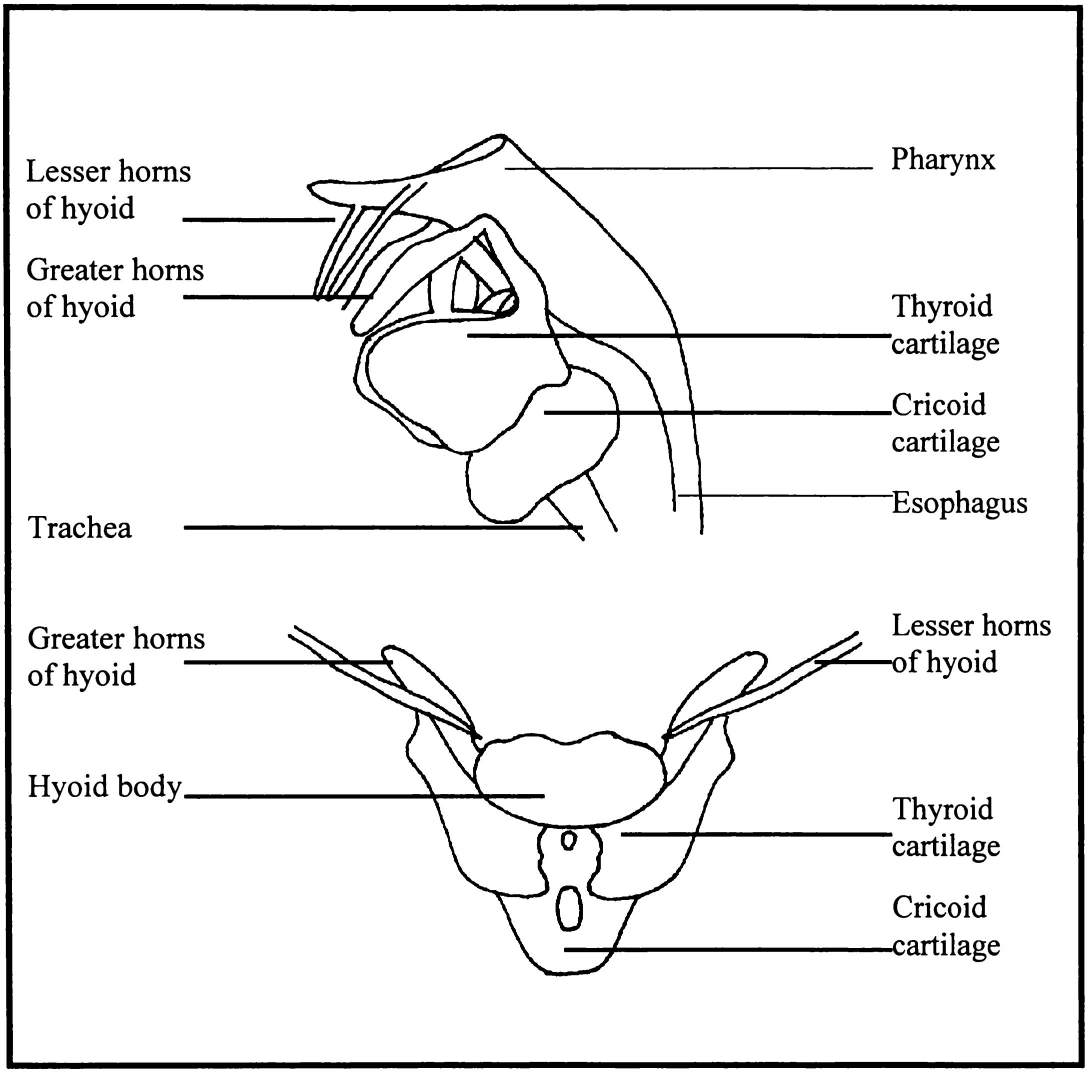

Figure 2.8 Left lateral (top) and anterior representations of the structures of the developing larynx at 50 days gestation. Adapted from Wind 1970.

the thyroid is comprised of two laterally positioned sections. The cricoid completely encircles the trachea and is situated cranial to the inferior border of the hyoid. The hyoid, at approximately seven weeks, appears as a large body with four prominent superodorsal projections emanating from the lateral aspects of the body. These relatively large precursors of the greater and lesser horns are the original second and third branchial arches (Wind, 1970). All structures of the human larynx are well represented by the end of the embryonic period; at eight weeks (Tucker and O'Rahilly, 1972).

Fetal maturation

The fetal stage beginning in the ninth week of gestational development is characterized by a gradual descent of the larynx and an increase in distance between the laryngeal components (Wind, 1970). At almost three lunar months of age, the larynx is demonstrably longer (see Figure 2.9). At this point in development, resulting from the transformation of mesenchyme, the majority of the laryngeal muscles are discernible. Elements of vocalization are vaguely recognizable as ovoid swellings located caudal to the arytenoids (Frazer, 1910). The corniculate and cuneiform cartilage precursors appear. The epiglottis is recognizable, though it this time is comprised of mesoderm, and not cartilage. At this developmental stage the thyroid cartilage has united along the caudal margin and the inferior horns are in articulation with the cricoid cartilage. Both of these structures exhibit thick walls. The relatively large hyoid body exists as a pre-

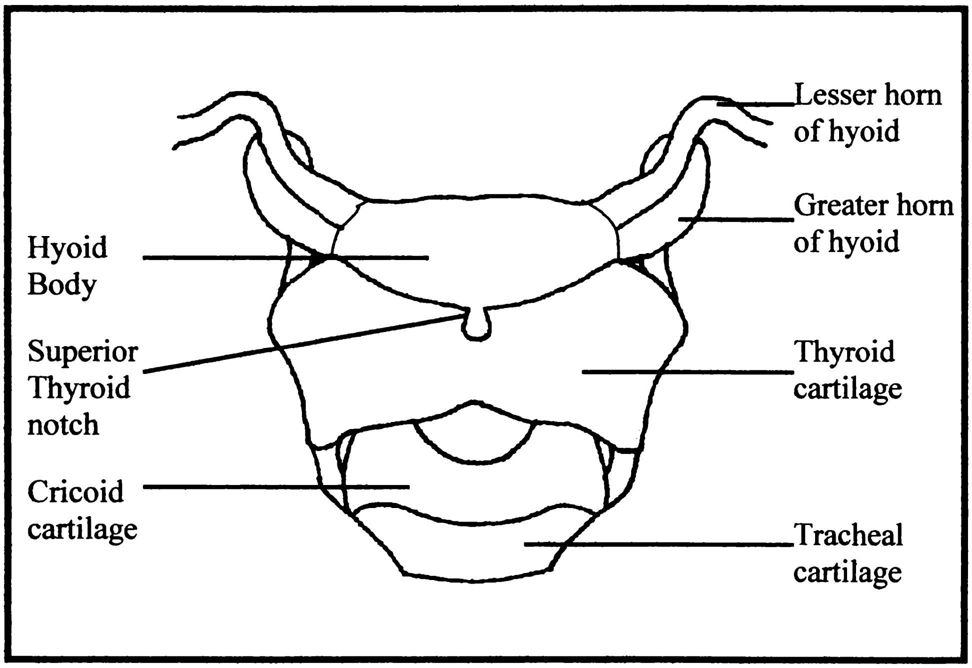

Figure 2.9 Anterior view of laryngeal structures at three months post conception. Adapted from Wind 1970.

cartilage tissue with the precursors of the greater horns maintaining a cartilaginous articulation with the upper horns of the thyroid cartilage (Wind, 1970). The derivatives of the lesser horns maintain a connection with the body via fibrous tissue (Koebke, 1978).

Throughout the early fetal stage maturation of the laryngeal structures continues. The two halves of the thyroid cartilage continue to fuse in a cranial direction resulting in the superior thyroid notch, which characterizes the completed form. The superior horns of the thyroid cartilage separate from the hyoid. During the fetal period the cricoid cartilage gradually decreases its bulky appearance while the cranial incisure which marks the anterior surface increases in depth. Relative to these structures, the arytenoid cartilages appear to decrease in size with the definitive form attained by 5 lunar months gestational age and maximum size by 7 lunar months. Chondrification of the epiglottis occurs at 5 lunar months, forming from fibroelastic cartilage and not hyaline cartilage, which, it has been suggested, signifies a non visceral arch origin for the epiglottis (Schaffer, 1907 in Wind, 1970).

During fetal development, the body of the hyoid bone decreases in prominence. The lesser horns of the hyoid no longer demonstrate a direct connection with the body, instead they are seen to join to the superior margin of the anterior greater horns. Koebke (1978) notes that at this time the juncture between the body and the greater horns is comprised of a layer of disc cells. At approximately five months of fetal maturation, Koebke (1978) proposes that a zone of closely packed blastemal cells exists between the body and the greater horn. He further suggests there are two distinct forms of connections between the greater horns and the body: a joint cavity and cartilagenous continuity, for fetuses at this stage of growth. Koebke (1978) notes evidence for either maintenance of a cartilagenous connection between the body and the greater horns, or the fusion of these components. The former is evidenced by fibrous tissue uniting the cartilagenous components while the latter is characterized by a transverse line of cells between the elements. Koebke (1978) theorized this is likely due to visceral arch origination, such that the body may develop from either the second and third arches or solely from the third arch.

Post natal development and maturation

At birth the components of the laryngeal complex generally appear as they do in the adult. The skeletal structures of the hyoid apparatus are cartilagenous with ossification occurring during childhood and early adolescence. At birth, the larynx is located in the anterior compartment between the first and fourth cervical vertebrae. Descent of the entire laryngeal complex characterizes the early post-natal period. This inferior elongation has been explained by the evolution of erect posture and growth of the splanchnocranium (see Wind, 1970). According to Westhorpe (1987), the larynx and hyoid bone descend to encompass the area between the second and fifth cervical vertebrae during the first three years of life, with further descent at the onset of puberty.

The growth of the thyroid cartilage at puberty is responsible for the further descent of the laryngeal complex to its location in the mature skeleton; the region associated with the caudal most five cervical vertebrae. During early childhood the lateral portions of the thyroid which earlier had exhibited a rounded ventral surface gradually begin to rotate such that the vertical ridge, the laryngeal prominence, appears. The remaining cartilage components continue to develop towards the structures that characterize the adult larynx, though in early childhood the epiglottis is still rather bulky. The cricoid however resembles the adult form early in the post-natal years.

The hyoid ossifies from six centers, two for the body and one for each of the greater and lesser cornu (Jackson, 1914). The sequence of the appearance of ossific centers throughout the components of the hyoid bone is generally accepted. Ossification first occurs in the body followed by the greater horns and finally by the lesser horns. Parsons, (1909) however, notes evidence of ossification of the greater horns prior to the body. Although the sequence is generally accepted, the specific timing of these events is not as well understood. Generally, the onset of skeletal mineralization of the hyoid body is commonly associated with the late fetal or early neonatal periods (see for example Jackson, 1914). However, Hill (1939) states that ossification of the body can occur as early as the fifth lunar month of fetal development though it occurs "more frequently" "usually" and "is present in most" during the sixth, seventh and eighth lunar months respectively (1939:270-1). Hill (1939) found that ossification of the hyoid body does not follow the general rule promoted by Todd (1937) that centers of ossification appear first in females.

> "No sexual differences exists between the incidence of the hyoid center in males and females and its incidence in any age group can be but hesitantly predicted" (Hill, 1939:264).

Reed (1993) found no evidence of ossification of the hyoid body in fetuses less than 30 weeks. Similarly Tompsett and Donaldson (1951) noted ossification of the body in 75% of neonates, as did Wells et al. (1986). Reed (1993) found evidence of the onset of ossification in all but one subject aged two months. During the first year of life, the lateral margins of the body tend to be triangular in shape given that ossification of the hyoid body progresses posteriorly along the superior margin of the body (Reed, 1993). The pattern of ossification extends downward and posteriorly resulting in the development of a more square shape for the body during childhood (Reed, 1993).

The appearance of centers of ossification in the greater horns is generally ascribed to the first half year of life, with ossification progressing posteriorly (Scheuer and Black, 2000). Parsons (1909) describes ossification of the greater horns progressing 1 centimeter (cm) during the first year of life and 1cm during childhood and 1cm between puberty and the twenty-fifth year. Complete ossification of the greater horns, more commonly ascribed to late childhood or early adolescence, results in a slightly bulbous posterior margin of the greater horns (Jelisiejew et al., 1968). Parsons (1909) notes a cartilagenous bulb at the posterior most margin in subjects to thirty years of age. The lesser horns exhibit tremendous variability with the centers of ossification appearing as early as the first or second year of post-natal growth (See for example Schaffer, 1953) although ossification generally does not occur until puberty (Parsons, 1909). The lesser horns can remain unossified throughout life (Scheuer and Black, 2000).

The junction of the body and the greater horns is characterized by a cartilagenous pad which ranges in thickness. Union of the hyoid body and the greater horns and fusion of the lesser horns to the body and or the greater horns is not seen during childhood. It is widely assumed that these zones, often referred to as synchondroses will, in succeeding years, ossify resulting in fusion between the structures (Macdonald-Jankowski, 1990). Schaffer (1953) suggests that the greater horns unite with body between the 25^{th} and 30^{th} years. The hyoid apparatus is traditionally presented such that,

> "the lateral borders (of the body) are partly in relation with the greater cornua, with which they are connected. Up to middle life by a synchrondrosis, but after this period, usually by bone" (Jackson, 1914:99).

Moreover, Johnson and Moore, note the greater horn "is connected with the body at first by hyaline cartilage but during adult life the union becomes ossified" (1989:123). Parsons concurs, and further suggests that fusion "often does so on one side long before the other" (1909:289). It is often suggested that the lesser horns fuse with the body and or the greater horns, though the latter is more often noted (Schaffer, 1953). Parsons (1909) notes that the lesser and greater horns are most frequently connected via a synovial joint.

In general, growth and development of the laryngeal complex during the childhood and juvenile periods occurs in a manner that is consistent with the maturation of other general body structures (See Bogin, 1999). According to Furmanik and coworkers (1976), throughout life structures of the human larynx vary in size and shape. Among humans, the primary difference between infant and adult larynges is apparent in the lateral regions, with the infant larynx positioned high in the neck, similar to other mammals, (Harrison, 1995). It has been suggested that this is attributable to diet, in that infants ingest a predominantly liquid diet which necessitates the existence of specific morphological features that function to protect the larynx (Harrison, 1995).

Descent of the larynx begins during the second year of life. The larynx of the child is narrower and shorter with the epiglottis exhibiting a more U-shaped form in comparison to the adult structure (Harrison, 1995). Tourne (1991) notes that the position of the hyoid bone in relation to structures of the craniofacial complex varies during life. King (1952) states that after puberty, the hyoid bone moves forward (see for review Bibby and Preston, 1981). In older individuals, the hyoid descends, likely attributable to an increase in the thickness of the tongue (Tourne, 1991). This lower position has also been noted in individuals who suffer from Obstructive Sleep Disorder (OSD) (see Kollias and Krogstad, 1999). Kollias and Krogstad (1999), note a significant decrease in vertical positioning with little or no change in the horizontal plane. Such would influence the musculature associated with maintaining the suspended position of the hyoid, potentially resulting in skeletal modification of the element. This examination of the gross morphology and the structural development of the elements of the hyoid bone is crucial as it provides a foundation with which to appreciate not only the morphology of the structure but the pathological and developmental conditions of the components of the hyoid bone.

Chapter III

Literature Review

Introduction

The human hyoid bone is described as forming the most prominent part of the larynx. Further referred to as the tongue bone, it was so named given its resemblance to the Greek letter upsilon *v* (Garrison and Hast, 1993). The first intensive consideration of the hyoid bone in the anatomical literature is credited to Andreas Vesalius in the middle sixteenth century. Early notations of hyoid bones, the name it implies unity, describe investigations of non human laryngeal structures (see Harrison, 1995 for a review). The accuracy of these early works is such that they are considered remarkable references. The following centuries saw the gradual incorporation of human specimens into these anatomical studies. These comparative examinations are exceedingly beneficial as such necessitate moving beyond mere descriptive anatomy to consider the structural, functional and adaptive significance of skeletal systems. Further, these investigations established a foundation for more thorough examinations of the human laryngeal structures, in particular the hyoid bone.

In addition to anatomical and functional examinations, the twentieth century has seen scientific considerations of the hyoid bone expand to include pathological interpretations, clinical assessments, developmental tendencies, forensic considerations, and anthropological investigations. To date however, the hyoid bone has been the subject of a broad spectrum of research objectives, which has generated substantial, though often insular information. Unfortunately, with increasing frequency, hyoid bone references in the literature involve isolated case studies or unique forensic and clinical situations. A review and synthesis of research concerning the hyoid bone will serve to clarify the development and functional significance of the structure and to facilitate more effective pathological and clinical examinations. In addition, a discussion of the laryngeal structures across the animal kingdom will serve to illuminate the phylogeny of the human laryngeal complex. Further, this comprehensive review will demonstrate the necessity and importance of the present examination.

Comparative Anatomy and Phylogentic Foundations

The earliest references in the scientific literature to the hyoid bone and associated laryngeal structures focus upon non human mammals. Galen, an anatomist from the Roman era (130-201 AD) explored the structures of animals conducting numerous non human dissections, while engaging in few human examinations. The anatomical structures of various animals, including primates, and notably, examinations of various carnivore larynges, were considered by DaVinci in the late fifteenth century, though not widely published until several centuries later. His anatomical findings were noted by Vesalius, one of the first to rely on human dissection, who incorporated physiological information from Galen in his 1543 publication *De Humani Corporis Fabrica Libri Septum* (See Garrison and Hast, 1993). Vesalius presents the larynx and the hyoid bone, though his references are to the structure in non-humans. Relying heavily upon the work of Galen, Fabricus, a Greek scientist, incorporated the findings from experiments and numerous dissections on birds and mammals, including apes, to draw analogies concerning human anatomy. However, the most detailed account of mammalian laryngeal anatomy is credited to Carlo Ruini, a senator of Bologna, for his 1598 description of the horse. At the close of the sixteenth century, Fabricus, who stressed the importance of comparative research, considered the role of the laryngeal structure in sound production and the generalized function and positional significance of the hyoid bone. These faunal accounts provided the data for early human interpretative examinations of the hyoid bone. These non-human anatomical considerations of the hyoid bone not only generated a wealth of information but further supported a growing interest in the human structure as evidenced by the work of Guiulio Casserius, Fabricus' successor (Harrison, 1995).

Throughout the 17^{th} and 18^{th} centuries, numerous individuals contributed greatly to knowledge of anatomical structures with several focusing upon components of the larynges. Casserius compared the larynges of humans, non-human primates and mammals; in total more than twenty species, accurately describing the cartilages and intrinsic muscles of the human larynx. In the late

16th century, Frisian Volcher Coiter urged comparative anatomy publishing results of dissections of various mammals, amphibians and aves; in excess of fifty species (Harrison, 1995). In the late seventeenth century, Tyson noted special adaptations of the larynx necessary for aquatic and air breathing species, furthering knowledge of anatomical structures of mammals (Harrison, 1995).

The work of Darwin in the 19th century and a focus upon comparative anatomy in London medical schools did much to increase understanding of the structural significance of non-human skeletal components. This greatly furthered the appreciation of human anatomy.

> "no one can acquire a clear insight into the physiology of human organs unless he have borrowed comparative anatomy… the powerful light which that interesting science can alone shed upon his researches" Medical Times, 1844 in Harrison, 1995:150.

The work of Victor Negrus, a surgeon of disease of the throat and nose at Kings College hospital in London, in the early twentieth century, led to the proposal that the larynx was a valve whose primary function was to protect the airway. Presented in the publication *The Mechanism of the Larynx* (1929), he further proposed a secondary role of the larynx was the generation of sound (Harrison, 1995). In the decades that followed, building on the work of Darwin, it became generally accepted that the morphology of an organism incorporates a basic structure characteristic of its group and uniquely defined by specific adaptations

(Harrison, 1995). Though structural similarities characterize the laryngeal complex across the animal kingdom, the human hyoid, in particular, has acquired a diverse function in comparison to other species.

Harrison (1995) theorizes that the laryngeal complex evolved to support changes in the respiratory apparatus with development of the lungs from an ancestral gill system. The simplest laryngeal structure, as seen in the lung fish, consists of a cartilagenous plate suspended from the vertebral column. The earliest amphibians possessed a cranium similar to fishes with evolutionary progress towards a broad skull with ventral parts of the branchial arches uniting with the ventral portion of the hyoid arch. This eventually gave rise to the hyoid bone and associated musculature which provides support for the tongue (Walker, 1987). Evolving from primitive fishes and amphibians, early terrestrial vertebrates possessed air-breathing mechanisms in addition to gill and skin respiratory capabilities. Improved adaptations to terrestrial life including increased activity and varied behavioral responses were reflected in cranial changes. This resulted, in part, from increased brain size and complexity and varied breathing and feeding mechanisms, in addition to an increased reliance upon the auditory and olfactory senses (Walker, 1987). Skeletally, these adaptations are related to a strengthened skull and lower jaw (Walker, 1987).

The movement towards increasing muscular activity necessitated a more complex and dynamic system with the ability to sustain a wider airway, which in mammals, was achieved through evolution of the ancestral visceral arch derivatives. This brought about the development of laterally positioned cartilages and an associated muscular network which provided for the opening and closing of the airway. These structures evolved into the cricoid cartilage, either articulating with or containing the arytenoid cartilages. Harrison and Denny (1985) proposed that the size of the cricoid cartilage is a product of the rate of respiration. More developed species evolved a protective structure, the thyroid cartilage, which ultimately articulated with the cricoid cartilage (Harrison, 1995). Further evolution led to the appearance of the epiglottis and the corniculate and cuneiform cartilages, which enable respiration during feeding. The generalized mammalian hyoid apparatus consists of several bony or cartilagenous components including the basihyal (body), and paired ceratohyals (lesser horns) and the thyrohyals (greater horns) (see Figure 3.1). These structures are embedded in tissues associated with the tongue musculature and are attached via ligaments, or a network of small bones (epihyal, stylohyals, and tympanohyals) to the styloid processes of the temporal bones (Walker, 1987, Weichert, 1970). Although the size and shape of the cartilages vary between species, this generalized system characterizes the basic laryngeal form across the mammalian class (Negrus, 1949).

The components of the hyoid bone of non-human mammals have been found to exhibit recognizable inter and intra species variation. Saber and Hoffman, (1985) in their study of six ruminant species, concluded that sufficient variation exists to differentiate between species of roe deer, mouflon, sheep, red deer, fallow deer, and goat. A generalized form is attributed to the pronounced tongue, with minor variations ascribed to feeding type and functional specialization (Saber and Hoffman, 1985). The ungulate hyoid is comprised of several skeletal components; a single basiohyoid and paired thyreohyoids and ceratohyoids, epihyoids, and stylohyoids (Saber and Hoffman, 1985). The osseous components are connected via the cartilagenous tympanohyoids the to cranial structures noted as the chain of ossicles in Figure 3.1. The basiohyoid is a short transversely oriented bar; the lateral aspects from which the thyreohyoids and ceratohyoids form dorsal and ventral, respectively, projections. The thyreohyoids are analogous to the greater horns (Saber and Hoffman, 1985). The epihyoids project rostroventrally from the ventral margin of the ceratohyoids. The stylohyoids are caudodorsal projections from the dorsal aspect of the epihyoids and constitute the largest component of the ungulate hyoid bone. The dorsal ends of the stylohyoids are marked by the cartilagenous tympanohyoids which project cranially, and the stylohyoid angle, the caudal location of muscle attachment (Saber and Hoffman, 1985).

Nickel, Schummer and Seiferly (1954 in Saber and Hoffman, 1985) state that among ruminant species the basiohyoid and the thyreohyoids are united. Sission (1975), however, reported that they fuse only among large ruminants and primarily with advancing age, further stating that in small ruminants the thyreohyoids are not maintained in firm attachment with the basiohyoid. Saber

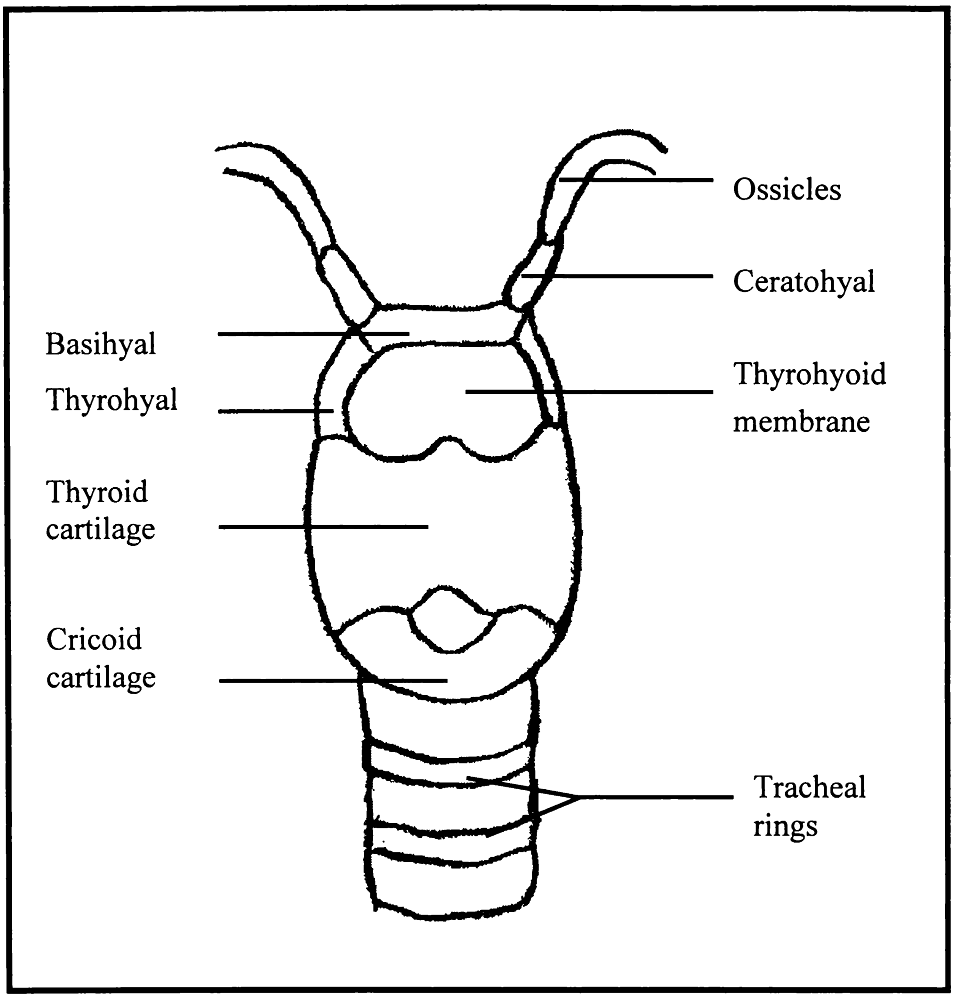

Figure 3.1 Ventral (anterior) view of generalized mammalian hyoid and associated structures. (Adapted from Walker, 1987).

and Hoffman (1985) define the thyreohyoids as lateral extensions of the basiohyoid, though they do ascribe sexual dimorphism to the structure in that the ceratohyoids of female ruminants demonstrate a medial angulation. They do not attribute any morphological features to specific feeding adaptations, instead concluding species differences are more related to overall body size and basic skull shape. Hoffman (1972 in Saber and Hoffman, 1985) and Stockman (1979 in Saber and Hoffman, 1985) suggest that, in fact, differences between species are attributable to feeding type and behavior.

Intraspecies variation for most species of the animal kingdom is based on size differences such that adult males possess larger laryngeal structures in comparison to females. This variation in size accounts for the differences in sound production (Harrison, 1995). Research has suggested that this disparity is a manifestation of androgen stimulation. Beckford et al., (1985) found that among young rams, variation in the amount of hormones is reflected in variation in the dimensions of the laryngeal cartilages. Studies by Audemorte et al., (1983) and Holt et al., (1986) suggest that such dimorphism is further attributable to the degree of sex steroid receptors in the laryngeal cartilage tissues such that varying hormonal levels influences development.

> "Growth of the mammalian larynx therefore appears to be controlled by both androgen and estrogen, possibly by modulation of genetic expression" (Harrison, 1995:76).

Nonetheless, morphological variation in the mammalian adult larynx has been primarily attributed to dietary activities (see Harrison, 1995). Hilloowala (1975) notes a direct relationship between diet and hyoid body size. Saber and Hoffman (1985) attribute morphological variation in the hyoid apparatus of ruminants to body size and skull shape. In addition to dietary practices, Wind (1970) suggests that the topography of the larynx is dictated by the need to maintain olfactory capabilities during eating given that the sense of smell functions as a self-defense mechanism for most animals. Further the structure of the larynx enables mammalian young to breathe and suckle simultaneously (Harrison, 1995). This practice is facilitated by the action of extrinsic tongue muscles which originate on the hyoid apparatus. Nakano and coworkers, (1988), following a study of mice, proposed that the mechanical stress of these muscles is the causal factor in the onset of ossification of the hyoid body.

In most vertebrates, the larynx is located just ventral to the base of the skull, whereas in higher primates it is displaced caudally, with humans exhibiting the most inferior position (Wind, 1970). This has been directly related to the existence of an upright posture across the *Homo* genus (Durzo and Brodie, 1962; Negus, 1949). An upright stance, however, alters the relationship between the hyoid and other structures. The lower position of the larynx in humans (three cervical vertebrate lower than most mammals) is a product of a shortened palate and the descent of the entire complex. This affords a greater capacity for nasal and/or oral breathing which subsequently enhances opportunities for the production of a wide range of sounds (Harrison, 1995). In humans given that the larynx is caudal to the tongue and forms the ventral border of the pharynx, its relationship to other organs differs from that of other species (Wind, 1970).

Falk (1975) examined the laryngeal complex of primates, humans and Neandertals as a means of determining the speech capabilities of Neandertals (see Leiberman, 1994; Leiberman and Crelin, 1971; Leiberman et al., 1972; Arensburg et al., 1989; Arensburg et al., 1990; Arensburg, 1994). Falk (1975) proposes that given the separation of the epiglottis from the soft palate in humans, the extrinsic tongue muscles and the arytenoids must function to elevate the tongue and close the vocal cords to prevent food particles from entering the larynx. He attributes the absence of this system among chimpanzees, who rely upon the epiglottis to shield the larynx, to a non-erect stance among non-human primates.

Nakano and coworkers (1988) suggest that the position of the hyoid among mammals reveal evolutionary trends within the mammalian class. The hyoid in both human and chimpanzee infants lies caudally to the gonial angle. In adult humans the hyoid occupies a more anterior position with the ventral most part of the body located at the midpoint of the horizontal radius of the mandible. In both of these groups, the hyoid planes are parallel. Adult chimpanzees exhibit a cranial angulation of the greater horns and a more posterior position such that the body is located at the gonial angle (Falk, 1975). Dubrul (1977) states normal functioning necessitates positioning of the hyoid plane lower than the mandible.

Stepovich (1965) defines the plane as the parallel line connecting the anteriormost point of the body along the long axes of the greater horns to the posterior tubercles. The length of associated muscles and the action of gravity upon the laryngeal complex determine the position of the plane. Further, this aspect of the human hyoid has been found to exhibit sex related differences with the hyoid positioned closer to the mandible and the base of the skull in females (Lykaki et al., 1989). Hilloowala (1975) supposes that the morphology of the hyoid is related to its proximity to the cranial base and its roles in both sound production and digestion.

A review of the literature concerning the laryngeal structures among non-humans demonstrates that developmental qualities and sex specific attributes characterize aspects of the mammalian larynges, particularly the hyoid bone. Further this confirms how functional specializations can account for and influence skeletal structures. An awareness of the developmental characters of the hyoid among mammals provides an avenue to potentially understand certain developmental features of the human hyoid structure.

Clinical Considerations

Most frequently, notations of the hyoid bone within the scientific literature relate to clinical examinations. The majority of clinical publications do not focus solely upon conditions of the hyoid bone, but more accurately consider the indirect role of the hyoid bone in body functions. Given the unique attributes of the hyoid bone as a suspended element with numerous muscle attachments, it provides structure and support for several functions of the neck region. The hyoid bone and its associated musculature is integral in maintaining the airway, in swallowing, in preventing regurgitation and in maintaining an upright stance (see Bibby and Preston, 1981).

References to the hyoid bone involve a broad range of syndromes (Rechtweg and Wax, 1998), abnormalities (Lykaki and Papadoulos, 1988), malformation (Sittel et al., 1998), and treatments (Gossman and Tarsitano, 1977; Van der Westhuijzen et al., 1999). Additionally, clinical considerations address the position and structure of the hyoid bone in relation to situations involving sleep disorders (Jamieson, et al., 1986; Lowe et al., 1997 and Tsuchiya et al., 1992). Notations regarding the position of the hyoid bone are also prevalent in the dental and orthodontic literature (Thurow, 1977 and Stepovich, 1965). Studies conducted within maxillofacial and oral surgery have also addressed the occurrence of tumors of the hyoid bone (Nakagawa et al., 1999). Although encompassing a broad range of topics, a review of clinical examinations of the hyoid bone will reveal aspects relevant to an understanding of growth and development of the structure.

Most frequently, abnormal and pathological conditions of the hyoid bone with associated pain are classified as Eagle's syndrome. First defined in the 1930's, the condition is primarily characterized by cervicopharyngeal pain and ossification/calcification of elongated styloid processes. Symptoms most often appear following trauma or tonsillectomy (Rechtweg and Wax, 1998). Van der Westhuijzen and coworkers propose that the term Eagle's syndrome, in fact, refers to three conditions with differing pathologies and symptoms (Van der Westhuijzen et al., 1999). They recognize, Eagle's syndrome, styloid syndrome, and pseudostylohyoid syndrome (Van der Westhuijzen et al., 1999). According to Van der Westhuijzen et al., Eagle's syndrome involves "elongated ossified styloid processes or stylohyoid chain ossification that specifically develops post-traumatically" (1999:335). The presentation of similar symptoms in the absence of trauma, i.e. a developmental anomaly, is classified as styloid syndrome (Van der Westhuijzen et al., 1999). Van der Westhuijzen and colleagues, recognize similar symptoms in older patients, whereby "because of ageing, a tendinosis develops at the junction of the stylohyoid ligament and the lesser cornua of the hyoid" (1999:335). As reported by Gossman and Tarsitano (1977) approximately 4% of the population is afflicted with the condition. Incidence of such conditions are primarily found in individuals over thirty years of age, though the greater number of cases are reported in subjects over forty years of age (Van der Westhuijzen et al., 1999).

Lykaki and Papadopoulos (1988) report on an individual with complete ossification of the stylohyoid ligament. This structure formed an osseus connection between elongated lesser horns of the hyoid bone and the styloid processes of the temporal bone. Therapies have involved several procedures for removal of either the styloid process or the lesser horns (Gossman and Tarsitano, 1977). The causation of such conditions is poorly understood though researchers suggest that improper development of Reichert's cartilage (Rechtweg and Wax, 1998) or a branchial arch anomaly (Ilankoran, 1987) may explain the osseous connector. Spontaneous fractures of ossified stylohyoid ligaments have been reported in the literature (Blomgren et al., 1999).

Clinical references to the hyoid bone commonly involve discussion of the position and location of the structure. Pae (1989) found that the hyoid bone occupies an inferior position in the larynx among individuals with obstructive sleep apnea, resulting from a reduced airway and an extended head posture. Similarly, Tsuchiya and coworkers, (1992) recognized an inferior and anterior location of the hyoid bone among subjects with severe obstructive sleep apnea, further noting, a correlation with body mass index. Although mean differences were observed between study groups, the relationship between apneic index, incidents of cessation of breathing during sleep longer than ten seconds in duration (see Lowe et al., 1997), and hyoid bone measurements was not statistically significant (Tsuchiya et al., 1992). Tsuchiya et al., (1992) attribute high incidence of obstructive sleep apnea to body mass index and skeletal abnormalities. However, Lowe and coworkers (1997) found, among other demographic and cephalometric variables, males with severe obstructive sleep apnea exhibit lower positioned hyoid bone. Five measurements of the location of the hyoid bone relative to the mandible and the third cervical vertebra indicate a lower position of the hyoid bone which impacts the function and mechanics of the hyoid musculature (Thurow, 1954)

A lower location of the hyoid bone influences muscle position and overall conditions within the neck region. In a study of 196 individuals (41 were controls), Jamieson et al. (1986) recognized lower displacement of the hyoid bone among patients with obstructive sleep apnea. Subjects also displayed retro-position of the mandible, acute anterior cranial base angulation (nasion to sella to basion) and elongated soft palates (Jamieson et al., 1986).

> "We hypothesize that the more acute NSBa angle...leads to abnormal development of the hypopharyngeal tissues associated with a lower position of the hyoid bone...In the same manner, alteration of the soft tissue may develop secondary to the conjoint effect of mandibular retroposition and acute cranial base flexure..." (Jamieson et al 1986:476).

Bibby and Preston (1981) present a mechanism for determining the position and location of the hyoid bone in relation to other elements within the neck region. Cephalometric points on the mandible, hyoid bone, and third cervical vertebra define the hyoid triangle. This model reflects the horizontal, vertical, and angular position of the hyoid bone. Bibby and Preston (1981) suggest such an objective and reliable technique is necessary to assess the effectiveness of orthodontic treatments and surgical procedures. In their study, Bibby and Preston did not recognize variation in the location of the hyoid bone between males and females, though they note the need for further examinations to study the effects of "age, race and posture on the position of the hyoid bone" (1981:97). Given that the hyoid bone provides attachment sites numerous for muscles, it is a significant variable in assessing and treating disorders. Further, an understanding of the developmental conditions, which involve the hyoid bone and associated soft tissues, is important to fully appreciate the structure.

Pathological Examinations

A substantial portion of published references to the human hyoid bone focus upon pathological and traumatic incidents. The position and the fragility of the hyoid bone and associated laryngeal structures make them susceptible to trauma. Commonly, laryngeal injuries are manifest in one of three types of damage: fracture of the hyoid bone, fracture of the thyroid cornua, and fracture of the thyroid and cricoid cartilages (Evans and Knight, 1981). Of particular importance is that external soft tissue trauma is not always associated with such injuries (Spitz, 1980). Specific laryngeal and craniocervical injuries have been associated with particular traumatic forces (see for example Evans and Knight, 1981 and Spence et al., 1999). Although the hyoid bone does not articulate with any other skeletal structures, it can be affected by a variety of compressive forces including ligature and manual strangulation, hanging, and direct blows to the neck (see for example Weintraub, 1961 and Evans and Knight, 1981). Moreover, it has been suggested that additional factors such as age of the subject and individual features of the larynges structures, i.e. shape, influence the likelihood and pattern of injury (see for example Evans and Knight, 1981; Pollanen et al., 1995; Pollanen and Chiasson, 1996; Pollanen and Ubelaker, 1997; Rodriguez, 1986; Ubelaker, 1992).

Evans and Knight state that fractures of the hyoid bone are "rare except as a result of direct trauma such as manual strangulation, hanging or direct blows to the neck" (1981:123). Weintraub (1961) noted hyoid fractures in 50% of cases of manual strangulation and 27% of hangings. Harm and Rajs (1981) found a strong association between strangulation and fracture of the hyoid with failure seen in 70% of manual strangulations and 42% of ligature strangulation. Paparo and Siegel (1984) found hyoid fractures in 16% of self inflicted hangings. Hansel recognizing hyoid fractures in 10% of strangulations concluded fracture likelihood is related to

> "the degree of ossification of the throat skeleton. This ossification starts often already at early age and should be considered as a process of aging" (1973:143).

Incidents of hyoid fracture have also been noted in situations involving falls (Spitz, 1980), industrial accidents (Dickenson, 1991), minimal trauma (Bagnoli et al., 1988), vomiting (Gupta et al., 1995), during resuscitative efforts (Gregerson and Vesterby, 1980) sports related injuries (Whyte, 1985 and Maran and Stell, 1970) ballistic trauma from hand guns (Carroll et al., 1992), and vehicular accidents (Graf, 1969; Zachariades and Mezitis, 1987; Khokholov, 1997; Szeremeta and Shahrokh, 1991). Additionally, several incidences of hyoid fracture have been associated with pharyngeal laceration (Eliachar et al., 1980; Krekorian, 1964; Olu Ibekwe, 1991).

Hyoid bone fractures comprise a mere 0.002% of all skeletal fractures and primarily result from direct impact trauma or sudden muscular movement (Bagnoli, et al., 1988; Guernsey, 1954). Fractures of the hyoid bone result from the application of tension and compression upon the soft tissues that attach to them, such that these forces stress the attachment sites and result in skeletal failure (Evans and Knight, 1981). Such forces can be attributed to direct impact upon the laryngeal structures (Bagnoli, et al., 1988), or result from sudden hyperextension of the neck (Padgham, 1988). Reports of fracture of the hyoid bone resulting from "muscular action alone (Olmstead, 1949:269) have been noted (Ashe, 1916).

Weintraub (1961) classified hyoid fractures in the following manner: resulting from inward compression, due to antero-posterior compression, or as avulsion fractures. Lakhia and coworkers (1991) identify the following clinical types of hyoid fractures: fractures through the body resulting from direct trauma, fractures of the lesser horn, and fractures of the greater horns. They further recognize fractures of the greater horn as closed with displacement inwards or outwards and compound; externally or into the pharynx (Lakhia et al., 1991).

Failure, i.e. fracture, of the horns occurs more frequently given they are less structurally sound than the body (Spitz, 1980). However, Spitz (1980) correlates failure with the rigidity of the structure (i.e. calcification and fragility) and professes that such is more likely to occur in elderly individuals due in part to the condition of the bony structures. Theoretically, a hyoid bone with mobility at the juncture of the body and the greater horns would be less likely to exhibit skeletal failure given that the joint would permit dispersion of a portion of the compressive and tensile forces. Porrath (1969) suggests that sudden hyperextension of the neck could cause muscle groups to exert forces upon the body and the great horn causing separation at the fibrous junction and resulting in displacement of the great horn with respect to the body. Spence et al., (1999), in an analysis of skeletal material from judicial hangings, noted fracture of the greater horn in an unfused specimen. Both Luke et al., (1985) and Simonsen (1988), however, conclude that fracture to the hyoid is less likely to occur among young individuals given that the components are unfused and thus the structure is more resilient.

Examinations of skeletonized hyoids have been conducted to assess whether any morphological characteristics increase the likelihood of hyoid fracture (see for example Pollanen et al, 1995; Pollanen and Chiasson, 1996; Pollanen and Ubelaker, 1997; Rodriguez, 1986). Pollanen and coworkers (1995) recognize several factors that influence the failure of the hyoid during strangulation. These include the magnitude and location of the force that is applied and the rigidity of the bone, further noting that incidence is low in children given incomplete ossification (Pollanen et al, 1995). Following an analysis of 19 fractured hyoids, Pollanen et al (1995) concluded that the overall shape in part determines the specific location of hyoid fractures with more fractures occurring within the middle and posterior sections of the greater horns.

Subsequent analysis sought to further identify morphological characteristics that are correlated with hyoid fracture (Pollanen and Chiasson, 1996). In a comparison of radiographs of twenty hyoid bones from victims of strangulation (10 with resultant hyoid fractures), Pollanen and Chiasson (1996) attributed the occurrence of fractures to intrinsic factors including shape and rigidity. Of fractured hyoids, 70% were fused where as among unfractured hyoids, 30% were fused. Pollanen and Chiasson state "this data indicates that age-dependent fusion of the hyoid bone increases the probability of hyoid bone fracture" (1996:111).

In addition, the shape of the hyoid was also determined to be a factor in failure of the hyoid bone. Pollanen and Chiasson (1996) state that fractures were noted more often in hyoids that were longer in the anteroposterior plane and more steeply sloping, i.e., more U-shaped than V-shaped. Pollanen and Ubelaker (1997) analyzed 100 skeletonized hyoids to further investigate the relationship between shape, as reflected by two measurements, and incidence of fracture. The normal shape data generated for the 100 hyoids indicates two categories: hyperbolic, or U-shaped, and parabolic, or V-shaped. The ten fractured hyoids investigated by Pollanen and Chiasson (1996) were compared to these normal specimens and indicated that, contrary to earlier findings, shape is not an important variable in determining likelihood of fracture (Pollanen and Ubelaker, 1997).

As suggested by Ubelaker (1992), the detection of hyoid fractures at autopsy can be difficult, particularly in the absence of hemorrhage. The medicolegal community primarily relies upon palpation and radiographic assessment in the evaluation of conditions of the hyoid bone and laryngeal structures (Khokhlov, 1997). In a review of 137 cases, Khokhlov (1997) found that these methods revealed less than 60% of injuries and further resulted in false diagnoses. He notes palpation can only reliably indicate fractures of the greater horns and at the same time this technique may yield incorrect results in incidences of "considerable mobility of the cornu" (Khokhlov, 1997:174). This statement illustrates the need for an accurate awareness of the morphological variability of the hyoid bone in pathological analyses.

Radiographic interpretation of hyoid trauma is difficult given that cervical vertebrae obscure the hyoid in anteroposterior oriented films (Pendergrass et al., 1956). Further, in this plane the greater horns are not fully represented which precludes a thorough analysis (Gordon et al., 1976). Although lateral projections illustrate the greater horns, Gordon and coworkers (1976) find that such obscures the juncture between the body and the greater horns. Accurate assessment thus necessitates careful removal of the larynx (Khokholov, 1997; Gordon et al., 1976).

> "Radiological examination may reveal an asymmetric ossification of the synchrondroses between the great cornu and the body of the hyoid bone. There is a great deficiency of data in the literature on how sex and ethnic differences may influence the time of ossification of the synchondroses. The ossification is not only asymmetric but sometimes proceeds by the formation of several bridges of bone across the synchondrosis" (Gordon et al., 1976:167).

Browne (1973) points out that it is very easy for the clinician to miss a fractured hyoid bone. Moreover, a precise investigation of hyoid elements requires investigators to maintain an unbiased position regarding the age and sex of the individual and further to recognize the morphological variability of the structure.

Anatomical and Developmental Research

A basic foundation for the majority of research within skeletal biology is that osseous elements exhibit characteristics which reflect stages of development and degeneration. The nature of these events is such that they can often be correlated with chronological age. Both during growth and with maturation, skeletal elements demonstrate morphological variation attributable to both structural growth and lifestyle. These developmental and degenerative features have demonstrated utility as indicators of age (See Reichs, 1998 and Stewart, 1979 for a review). Similarly, skeletal attributes vary such that certain morphological features have been correlated with sex. Generally this is such that male skeletons exhibit greater robusticity while female skeletons demonstrate a tendency towards retention of juvenile features (see Iscan and Helmer, 1988 for a review). Further, examinations have demonstrated that specific skeletal traits are correlated with ancestry (see Gill and Rhine 1990, for review). These basic concepts have enabled skeletal biologists to construct associations between skeletal features and age, sex, and ancestry; i.e., to recognize skeletal markers of the human biological profile.

Several anthropologically based studies have been conducted to investigate whether components of the laryngeal structures, in particular the hyoid bone, demonstrate age, sex or ancestral related differences (see for example Furmanik et al., 1976; Miller et al.,1998; Bennett and Marks, 1998; Guilbeau, 1992; Komenda and Cerny, 1990; O'Halloran and Lundy, 1987; Parsons 1909; Wortman, 1889). Additionally, research designed to investigate more diverse issues has yielded demographic information of the human hyoid bone (see for example Papadopoulos et al., 1989 and Pollanen and Chiassen, 1996; Pollanen et al., 1995). A synthesis of these examinations conducted over the last one hundred years will illuminate whether sex and age correlate with developmental and degenerative features of the human hyoid bone.

Ancestry

Wortman (1889) proposed that differences are evident in the anatomical structure of the hyoid bone across populations. He stated that fusion of the body and greater horns is rarely seen (12%), among middle age "ancient Pueblo

Indians of Arizona" (1889:81) while 66% of Blacks exhibit "early bony union of these parts" (1889:82). With the exception of the work of Wortman (1889) few references mention differences between populations. Although Wortman states that the hyoid has been ignored by anthropologists, it does contains characters that are effective "in the matter of racial distinction" (1889:81). Unfortunately, such has not been tested. This is primarily attributable to the limited representation of individuals of differing ancestry within experimental collections.

Sex

Examinations of the human hyoid indicate that differences between male and female specimens are predominantly attributable to variation in overall size. Jelisiejew and coworkers conclude that "sex dimorphism of the characteristics of the hyoid bone is distinct" (1968:181). Subsequent researchers have attempted to further investigate variation in size (see Miller et al., 1998), and shape (see Papadopoulos et al., 1989), and to construct discriminant functions for sex estimation (see Guilbeau, 1992).

Parsons, in a study of 81 adult hyoid bones, found that "it is generally possible to tell the sex of a hyoid bone" based on measurements of the hyoid body (1909:280). He examined 53 males and 28 females over 20 years of age (see Table 3.1). Values of the transverse width of the hyoid body averaged 2.6 centimeters (cm) and 2.2 cm for males and females respectively. These values

Table 3.1 Dimensions related to sex as collected by Parsons (1909). Ages are pooled. Specimens are over age 20 years.

Measurement	***sex***	***mean***	***minimum***	***maximum***
transverse body width	male	2.6*	2.1	3
	female	2.2	1.7	2.6
height of the body	male	1.2	1	1.6
	female	1	0.9	1.2

* measurements are in centimeters

exhibit a high degree of overlap between male and female subjects. Heights of the body measurement values reflect a similar trend. Parsons' indicates that males specimens exhibit longer greater and lesser horns than females. However, he states that great variation and overlap is noted for the greater horns. Although Parsons' claim that the "normal shape and size of male and female hyoids have been established by a series of careful measurements" (1909:290), his investigation does not differentiate between the age of individuals, merely recognizing specimens as "adults." Although the mean values he records indicate there are differences between male and female subjects, there is a high degree of overlap which reduces the statistical significance of his findings.

Jelisiejew and coworkers (1968) analyzed 241 hyoid bones, 154 males and 89 females ranging in age from birth to 82 years. Six measurements were performed on skeletal and radiographic material. Length and width of the entire element, length and height of the body and length of the greater and lesser horns were collected. They found sex related differences appear in the 16-20 year old age group with male specimens exhibiting greater dimensions. Among adults (21-82 years), the average length (transverse measure) of the body is 26.3 mm for males and 22.5 mm for females. The length of the body as measured here is synonymous with the width of the body found by others to be sexually dimorphic. Mean values for the height of the body are 10.1 mm for males and 8.9 mm for females. All are statistically significant (Jelisiejew et al., 1968) (see Table 3.2). Jelisiejew et al., (1968) found the length of the bone to differ significantly between the sexes with mean values of 40.4 mm and 35.4 mm for males and females respectively. The distance between the posterior horns (defined by Jelisiejew et al., as width of the bone) similarly demonstrates significant sexual dimorphism with mean values of 36.2 mm for males and 32 mm for females. Average measures for length of the greater horns are 32.7 mm for males and 29.3 mm for females. This trend reflects a reversal of what is noted among sub-adults, where females exhibit longer greater horns. Calculation of coefficients of discrimination for the measurements indicates that the greatest degree of sexual dimorphism occurs in the length of the bone, followed by the length of the greater horn, and the length of the body (Jelisiejew et al., 1968). The measures of the length of the bone and the length of the greater horns are

Table 3.2 Dimensions related to sex as collected by Jelisiejew et al.(1968). Values are pooled by age; ranging between 21 and 82 years.

Measurement	***sex***	***mean***	***Difference of means***
Length of bone	male	40.4	0.29
	Female	35.4	0.44
Width of bone	male	36.2	0.55
	female	32	0.53
Length of the body	male	26.3	0.35
	female	22.5	0.26
Length of the greater cornua	male	32.7	0.24
	female	29.3	0.29
Height of the body	male	10.1	0.18
	female	8.9	0.17
Length of the lesser cornua	male	8.5	0.36
	female	7.05	0.4

* measurements are in millimeters

very comparable and in fact overlap as both incorporate the length of the greater horns. Jelisiejew and coworkers, (1968) indicate differences do exist in the overall dimensions of the hyoid bone between males and females. However, they do not separate the data by age (other than sub adult and adult divisions) which precludes recognition of the potential influence of development and degeneration upon the hyoid.

Papadopoulos and coworkers (1989) suggest that a normal shape can not be ascribed to the hyoid bone and fault the literature for failing to promote the true variability which they conclude characterizes the shape of the adult hyoid. A series of five measurements were performed on a set of seventy-six hyoids to reflect overall shape. These data enabled Papadopoulos et al. (1989) to recognize five common shapes which further exhibit sexual dimorphism. The two shapes most commonly ascribed to the hyoid bone, U and horseshoe shaped were not the most frequently observed. Male specimens were most often, 47%, classified as D (deviating) such that

> "The anterior part is a half circle...but posteriorly, one or both greater horns deviate to one or to the other side" (Papadopoulos et al. 1989:251).

Among female specimens, 32% were classified as H (horseshoe) and also B (resembling a transverse section of a boat) characterized as nearly half circle in shape (Papadopoulos et al. 1989). They further recognize asymmetry in approximately half, (47.4%) of the specimens, noting that it is equally represented among males and females (Papadopoulos et al. 1989). Half of all specimens exhibit anisometry such that the greater horns not equal in measure. Papadopoulos and coworkers (1989) state that the shape of the hyoid bone is more varied than is suggested in the published literature.

Komenda and Cerny (1990) attempted to determine sex from the hyoid bone by means of discriminant analysis. A series of six measurements were performed on 208 male and 138 female adult (over 20 years in age) hyoid bones. Height and width of the body, length of the greater horn and height of the anterior end, distance between the posterior ends of the greater horns and length of the lesser horns were recorded. Komenda and Cerny suggest that the two measures of the greater horns and the width of the body misclassify specimens less than five percent of the time and conclude the technique "proved its high efficiency comparable with other systems" (1990:49). Panhuysen and Bruintjes (n.d. in Reesink et al., 1999) in a study of archaeological specimens concluded that the length of the greater horn exhibits sexual dimorphism.

Similarly, Guilbeau (1992) proposes that discriminant analysis is effective for determining the sex of hyoid bones. Applying five measurements, body height, width and thickness and length of both left and right greater horns he recorded 90% and 100% correct classification for males and females, respectively. Sample sizes were 29 and 10 for males and females, respectively. When using hyoid body measurements only, Guilbeau (1992) recorded accurate classification of 87% for males and 95% for female specimens. Although these studies found differing measures to be effective, both researchers incorporated dimensions of the width of the body and the length of the greater horns into diagnostic discriminant functions.

Reesink and coworkers (1999) performed thirteen measurements on radiographs of fifty-nine hyoids to assess the reliability of the hyoid bone as an indicator of sex. They note that only thirty-nine specimens are subjected to statistical analysis. Reesink et al., (1999) found three variables, "maximal medial height of the corpus", "anterior posterior thickness of the corpus" and "maximal transverse diameter of the corpus" exhibit statistically significant differences between sexes. Employing a cross validation model, Reesink and colleagues found overall correct classification of 30 of 39 specimens, at 76%; 72% for males and 82% for females.

Miller et al., (1998), however, found that the use of discriminant functions were not highly effective in the differentiation of hyoids by sex, with an accuracy of only 69.2 % for males and 75.2% for females. Miller and coworkers, (1998) analyzed three hundred fifteen digitized hyoid radiographs to assess sex and age variation of the structure. Thirty measures were recorded with the majority of dimensions reflecting simply that males tend to be larger than females. They found this was most true for length measures. Although such measures are reflective of overall shape, Miller and coworkers do not recognize the existence of defined shapes and note that hyoid shape variation is continuous and specimens cannot be typologically classified based on shape.

Miller and colleagues, (1998) do not recognize sexual dimorphism for the posterior horn distance. This is consistent with the findings of Furmanik et al., (1976) who concluded that the dimensions of the middle laryngeal cavity (span of greater horns) do not exhibit significant sexual dimorphism. Similarly measured by Komenda and Cerny (1990), their data do not demonstrate a high degree of sexual dimorphism for width measurements of this region. Further, Miller et al., (1998) do not ascribe value to the length of the greater horn as a predictor of sex; in contrast to findings noted by other researchers. They, do however, state that the distal ends of the greater horns are one of the most sexually dimorphic aspects of the hyoid, with females recording larger values than males. Miller and coworkers suggest, however, that this may be a product of age distribution for their sample. Further given that the technique employed by Miller et al., (1998) incorporated measurements of radiographs, this reflects the hyoid in two dimensions, potentially obscuring sexually dimorphic qualities.

Overall, this literature review demonstrates that morphological variation does in fact characterize the human hyoid. Certain aspects of the human hyoid appear to demonstrate greater degrees of sexual dimorphism. In particular these include attributes of the body, with males generally larger in size than females. Unfortunately, several of these studies do not consider the potential influence of age in their interpretations. Moreover, small sample sizes with limited representation of certain demographic groups may reduce the significance of their findings.

Age

The dominant theme of age related considerations of the hyoid bone involve the timing of the union of the body and the greater horns. This is in following with the majority of investigations designed to elucidate skeletal age markers which focus upon the fusion of skeletal components (see for example McKern and Stewart, 1957). Such assessments of union, primarily, between diaphyses and epiphyses established the concept that synotoses occur with advancing age. This consideration has been applied to examinations of the hyoid bone such that investigators have sought to discern the timing of fusion of the body and the greater horns (see for example Jelisiejew et al., 1968; Miller et al.,1998; Guilbeau, 1992; Komenda and Cerny, 1990; O'Halloran and Lundy, 1987; Parsons 1909). Of interest is the fact that the majority of standard anatomical texts present the hyoid bone as an element that fuses with advanced age. A review of the literature concerning age and hyoid development and degeneration is not only crucial to the study at hand, but will serve to demonstrate the variation which typifies this structure.

The most commonly cited study concerning age and hyoid bone characteristics is the visual assessment of three hundred hyoid bones collected at autopsy by O'Halloran and Lundy (1987). They noted a degree of osseous fusion, unilateral (one fused) or bilateral (both fused) , in approximately half of the specimens which range in age from 2 months to 92 years (see Table 3.3).

Table 3.3 Occurrence of fusion by age and sex as identified by O'Halloran and Lundy (1987).

Age	Males				Females			
	N	Not Fused	Both Fused	One Fused	N	Not Fused	Both Fused	One Fused
0-9	3	3 100 %	0	0	3	3 100 %	0	0
10-19	22	22 100 %	0	0	4	3 75 %	0	1 25 %
20-29	49	34 69.4 %	9 18.4 %	6 12.2 %	17	10 58.8 %	3 17.6 %	4 23.5 %
30-39	50	20 40%	21 42 %	9 18 %	13	3 23.1 %	2 15.4 %	8 61.5 %
40-49	40	11 27.5 %	17 42.5 %	12 30 %	13	5 38.5 %	2 15.4 %	6 46.1 %
50-59	31	11 35.5 %	17 54.8 %	3 9.7 %	9	3 33.3 %	4 44.4 %	2 22.2 %
60-69	14	2 14.3 %	10 71.4 %	2 14.3 %	9	2 22.4 %	2 22.2 %	5 55.6 %
70+	16	4 25 %	10 62.5 %	2 12.5 %	7	2 28.7 %	4 57 %	1 14.3 %
Totals	225	107 47.6 %	84 37.3 %	34 15.1 %	75	31 41.3 %	17 22.7 %	27 36 %

Fusion was generally not noted in specimens less than 30 years in age. O'Halloran and Lundy (1987) state that the likelihood of fusion increases with age up to the sixth or seventh decade. They note bilateral fusion occurs more frequently among males, while females exhibit a higher occurrence of unilateral fusion. O'Halloran and Lundy (1987) claim that unilateral fusion occurs with high frequency following the third decade, however, it is important to note that among elderly females the frequency of no fusion and bilateral fusion are compatible. They do recognize that "significant numbers of middle-aged and elderly people, especially women, have nonunion" (O'Halloran and Lundy, 1987:1657). O'Halloran and Lundy (1987) recognize a high occurrence of unilateral fusion in women, which they note is of great importance to the forensic pathologist. However sample size averages less than ten per age group.

Jelisiejew and coworkers, (1968) analyzed the frequency of synchondroses or synotoses (fusion) between the body and the greater horns in three hundred and four hyoids (see Table 3.4). They conclude that fusion occurs earlier in males than in females. However, in advanced age, more females exhibit fusion (Jelisiejew et al., 1968). Though Jelisiejew and coworkers (1968) state the likelihood of fusion increases with age, the data do not unequivocally support this conclusion. Among males aged 61-70, only 39% of specimens exhibit fusion, whereas 42% of those aged 21-30 demonstrate fusion. In addition, Jelisiejew et al., (1968) did not note any significant differences between the sexes regarding unilateral fusion. Further, they did not note any significant

Table 3.4 Occurrence of fusion by age and sex as identified by Jelisiejew et al. (1968).

Age	***Males***		***Females***	
	Specimen Number	***Fusion (percentage)***	***Specimen Number***	***Fusion (percentage)***
0-20	32	2 (6%)	28	-
21-30	38	16 (42%)	12	1 (9%)
31-40	40	15 (38%)	18	3 (17%)
41-50	38	13 (34%)	16	7 (44%)
51-60	66	37 (56%)	20	14 (70%)
61-70	52	20 (39%)	48	26 (54%)
71-80	38	21 (55%)	36	22 (61%)
Totals	304	124 (41%)	178	73 (44%)

age correlation with unilateral fusion. Guilbeau (1992) claims that among males the incidence of fusion increases with age and in fact, among both sexes, bilateral fusion is more common than unilateral fusion or non-fusion among those over 50 years of age.

Parsons (1909), in his study of 108 hyoids, noted an incidence of unilateral fusion as early as the second decade (see Table 3.5). He ascribes bilateral fusion to the period beginning in the third decade, though rarely before

Table 3.5 Incidence of fusion by age as identified by Parsons (1909)

Age	*Specimen Number*	*Unilateral Fusion (percentage)*	*Bilateral Fusion (percentage)*
<20	30	1 (3.3%)	-
21-30	13	2 (15.4%)	-
31-40	16	5 (31%)	2 (12.1%)
41-50	12	1 (8.3%)	6 (50%)
51-60	22	3 (13.6%)	8 (36.4%)
61-70	13	2 (15.4%)	5 (38.4%)
>70	3	-	3 (100%)
Totals	98	14 (14.3%)	24 (24.5%)

the fifth decade. Parsons does not present data to differentiate between the sexes regarding incidence of fusion. He does, however, note that there is no difference between left and right sides in cases of unilateral fusion. Consideration of the data presented in Table 3.5 does suggest that no fusion was noted for 11 or 50% of his 51-60 aged specimens and for 6 or 46% of his 61-70 aged specimens.

> "It is however, a common thing to meet with people between 60 and 70 in whom the body and greater cornu of the Hyoid are quite separate, though in earlier decades (up to 35) the bony elements are usually separated by a buffer of cartilage 3 to 5 mm thick which later becomes a mere line" (Parsons, 1909:285).

Furmanik and coworkers (1976) in a study of 100 laryngeal wax casts, concludes that the dimensions of the middle laryngeal cavity increases with age. Attempting to develop equations to estimate the size of the laryngeal cavity for use in clinical applications they conducted five measurements. They note that the size of the middle laryngeal cavity is strongly correlated with the span of the greater horns thereby suggesting that this dimension of the hyoid increases with advancing age.

Miller et al., (1998) assessed the level of fusion at the juncture between the greater horn and the body on three hundred fifteen hyoid radiographs with respect to age and sex (see Table 3.6). They note "considerable age variation in fusion of the greater cornua to the hyoid body" (Miller et al., 1998:1138). Specifically, among unfused specimens, they recognize a significant decrease in the joint space between the great horns and the body, though only up to age 40 years. Furthermore, their results contradict those of others as Miller and coworkers (1998) did not note any significant evidence for sex differences regarding onset of bilateral fusion. Although they recognize that the proportion of bilateral fusion increases with age, Miller et al., note that "bilateral nonfusion

Table 3.6 Incidence of fusion by age and sex as identified by Miller et al., (1998).

Age	***Males***			***Females***		
	Not Fused	***Both Fused***	***One Fused***	***Not Fused***	***Both Fused***	***One Fused***
0-10	2 100 %	0	0	2 100 %	0	0
11-20	29 100 %	0	0	6 100 %	0	0
21-30	22 71%	5 16.1 %	4 12.9 %	12 70.6 %	3 17.6 %	2 11.8 %
31-40	14 38.9%	11 30.6 %	11 30.6 %	6 37.5 %	5 31.3 %	5 31.3 %
41-50	6 20.7 %	13 44.8 %	10 34.5 %	11 50 %	4 18.2 %	7 31.8 %
51-60	8 32 %	11 44 %	6 24 %	7 35 %	10 50 %	3 15 %
61-70	5 23.8 %	11 52.4 %	5 23.8 %	5 25 %	10 50 %	5 25 %
71-80	5 33.3 %	9 60 %	1 6.7 %	6 26.1 %	12 52.2 %	5 21.7 %
Totals	91 48.4%	60 31.9 %	37 19.7 %	55 43.7%	44 34.9 %	27 21.4 %

persists in a significant proportion of the elderly population" (1998:1139), finding it in 30% of specimens over 70 years of age. Miller and coworkers, suggest that this cannot be explained by regarding fusion between the body and the greater horns as an ongoing process (1998). Instead they state that "People may have a genetic predisposition to fusion or non-fusion" (1998:1139).

This review indicates that there is a potential need for a study of the correlation between age and fusion. The limited sample sizes and slightly contradictory trends in fusion warrant a more thorough examination, incorporating a large sample. Furthermore, the data are cross sectional and all investigators consider their data such in a longitudinal fashion. Obviously, it is not possible to construct a longitudinal sample. However, this must be considered in data interpretation.

Conclusions

Investigations and evaluations of the laryngeal structures, in particular the hyoid bone, address a wide variety of subjects including clinical, pathological and developmental aspects. Undeniably, all such interpretations require an accurate awareness of the anatomy of the laryngeal components. Although this literature review presents substantial information concerning the composition of the larynges stemming from a wealth of research, it also demonstrates the lack of consensus among investigators regarding the structure and development of the skeletal component of the larynges. As discussed herein, researchers have suggested that anatomical aspects and developmental conditions of the hyoid are related to sex and age. However, such investigations have yielded controversial and occasionally opposing findings. Further, the use of radiographic versus skeletal data prohibits a truly comparative assessment of the findings (see Table 3.7).

A review of the literature concerning the hyoid bone indicates there are several morphological attributes with potential developmental correlates. To date, however a large-scale investigation has not been conducted to thoroughly assess these viewpoints. Previous researchers have suggested that span of the greater horns, i.e. distance between the posterior-most projections of the thyrohyals may evidence dynamic qualities during maturation. Reports have also attempted to demonstrate that size attributes are correlated with sex. However, lacking from such interpretations is to what degree age influences variation in size.

In addition, investigations suggest that the fusion between the body and the greater horn may have age related significance. However, absent from such assessments is consideration of whether union of the elements occurs in stages or follows a pattern. Unfortunately, published investigations addressing the timing of fusion employ cross sectional data in a longitudinal manner; i.e. comparing evidence of fusion between age groups. Instead, the prevalence of fusion must be considered within age groups as the timing of union of the elements may reflect natural variation in the human species.

Table 3.7 Summary of primary anatomical and developmental studies

Author(s)	*Year*	*Sample*	*Study synopsis*
Parsons	1909	53 males* 28 females*	States hyoid body measurements reflect sex of specimen. Considers age and fusion status
Jelisiejew et al.	1968	136 males* 75 females*	Conclude sex differences exist in overall dimensions of hyoid bone. Suggest fusion increases with age
Komenda and Cerny	1990	208 males 138 females	Discriminant analysis for sex by six measures.
Guilbeau	1992	29 males 10 females	Classification in excess of 90% using five measurements of hyoid
Reesink et al.	1999	59, 39 used in analysis	Radiographic examination with 76% correct classification by sex
Miller et al.	1998	315	Digitized hyoid radiographs. approximately 70% correctly classified. Thirty measurements. Consider age and fusion.
O'Halloran and Lundy	1987	225 males 75 females	Considered age and fusion status. State likelihood increases with age

*Refers to adult specimens only

The hyoid bone has long been erroneously presented as a single U shaped bone that fuses with age. A synthesis of the literature suggests that this has been blindly accepted, which further demonstrates the need for a large-scale evaluation of the hyoid bone to consider size, shape and fusion with regards to sex and age. This study is designed to explore these concerns; to illuminate the developmental and degenerative qualities and the morphological variation inherent in the human hyoid.

Chapter IV

Materials and Methods

Introduction

Hyoid bones were subjected to a twofold examination designed to investigate the developmental patterns inherent in this osseous laryngeal structure. The extent of union between individual components of each hyoid was evaluated with respect to age, sex and ancestry. Additionally, overall morphology was assessed to discern the range of morphological variation which characterizes the hyoid bone. Further investigation sought to illuminate patterns of fusion and to demonstrate the developmental and degenerative qualities of the bony component of the larynges. In total, 1,814 hyoid specimens, from three collections, were subjected to both metrical and visual evaluation to illuminate patterns of development of the hyoid apparatus. The visual examination involved determination of the level of fusion of the hyoid, i.e. between the greater horns and the body, through a two-phase assessment constructed to investigate the existence of any progression or patterns of fusion. Additionally, the span of the greater horns was assessed to illuminate any correlation between advancing age and structural modification. The metric analysis consisted of a suite of five measurements designed to reveal overall size and shape. Subsequently, data were analyzed using standard statistical protocol to assess whether any patterns of development were apparent and secondly whether such patterns were statistically significant regarding age, sex and ancestry. In addition, statistical evaluation was performed to investigate the existence of sexual dimorphism and morphological variation of the hyoid bone.

Sample

The sample is comprised of skeletonized hyoid specimens from three separate osteological collections curated by the Department of Anthropology at The University of Tennessee, Knoxville. The study sample includes a total of 1,814 skeletonized hyoid specimens. A total of 1,722 bones from the Osteopathology Evidentiary Collection (OPC) (collected from 1986-1998), 68 hyoids from the William M. Bass Donated Skeletal Collection (WMBDSC) (collected from 1981-2000), and 24 hyoids from the William M. Bass Forensic Osteological Collection (WMBFOC) (from casework conducted from 1962-2001), were examined. Figure 4.1a illustrates the collections used in the study sample and further reflects the components of each collection represented by males and females. See Appendix A for a listing of all specimens.

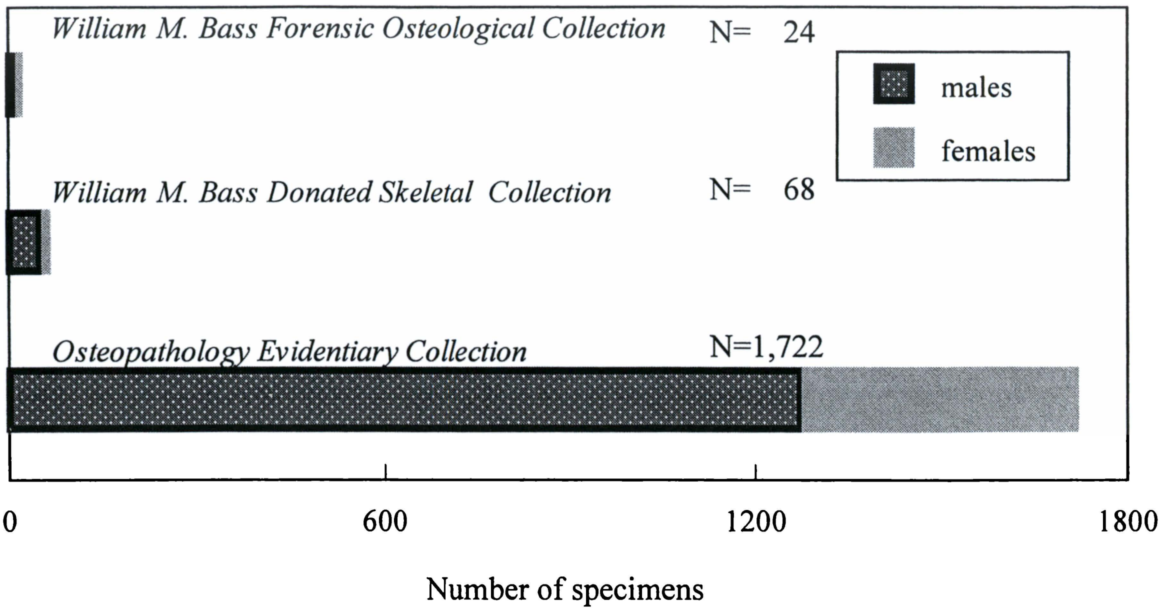

Figure 4.1 Number of each sample used in this study.

Sex of decedents was assigned a numeric value; females 1 and males 2. Age was reported in years. Those specimens with an age at death of less than one year were aged in tenths of a year. Specimens were categorized into ten year age groups: 0-9, 10-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89 and 90+ years. Ancestry, as reported by the medical examiner, was coded using a numeric system: Whites 1, Blacks 2, Asians 3, Hispanics 4, and Native Americans 5. Individual identities of all of the decedents are unknown. See Appendix A.

Osteopathology Evidentiary Collection

The Osteopathology Evidentiary Collection consists of skeletal elements dissected during autopsy at the James H. Quillen College of Medicine, East Tennessee State University, Johnson City, Tennessee, from 1986 through 1998. The collection, presently curated at The University of Tennessee, Knoxville, was collected at autopsy by Dr. William F. McCormick. Following necropsy, elements were prepared by immersion in a 5.45% solution of sodium hypochlorite for two to four hours to facilitate removal of remaining soft tissue. Elements were then rinsed, air dryed and placed in labeled bags (personal communication, McCormick, 1998).

Hyoids used in this study were collected from 1986 through 1998, though no material is available from the years 1990 and 1991. Specimens collected during the period from 1986 to 1993 include both ossified thyroid and cricoid cartilages. Age, sex, and ancestry are known for all decedents. Cause and manner of death are known in most cases.

A total of 1,722 hyoids were examined. Males comprise 74% (1278). Females comprise 26% or 444. Ninety-five percent (1633) of the specimens are White, and 4% (75) are Black. Subjects of Asian, Hispanic, and Native American ancestry each represent less than one percent of the collection sample (See Figure 4.2). See Appendix A for demographic profile.

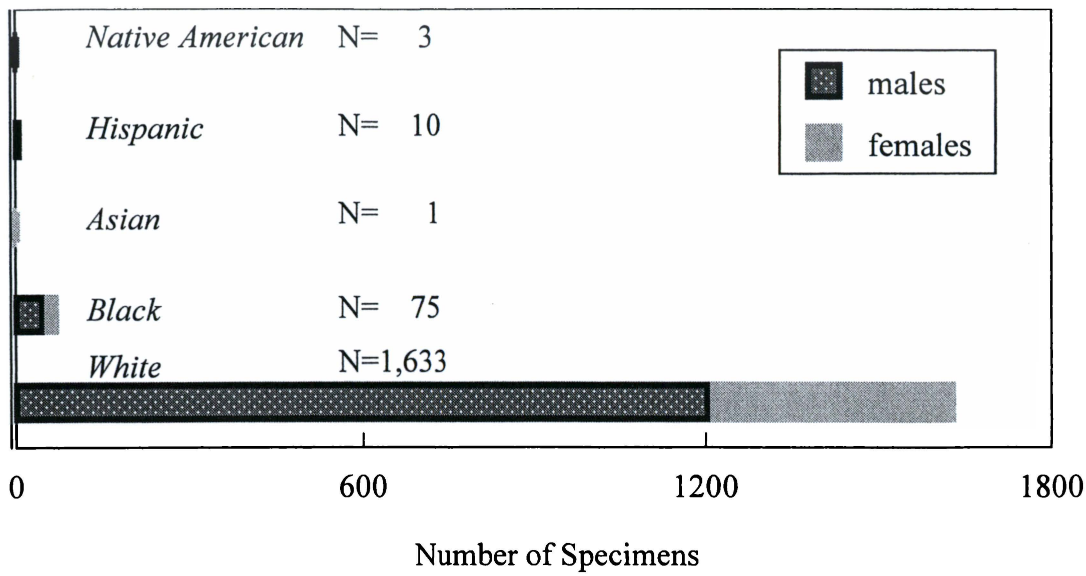

Figure 4.2 Demographics of the Osteopathology Evidentiary Collection Hyoid Specimens.

Specimens range in age from 2.5 months to 101 years with an average age of 43.8 years; 43.9 for females and 43.8 for males. The median age is 43 years and the mode is 36 years. See Figure 4.3 for an age profile of specimens.

William M. Bass Donated Skeletal Collection

This collection is comprised of self and familial donated individuals and decedents received through the State of Tennessee Medical Examiner system dating from 1981 through 2000. Subjects were exposed to the natural

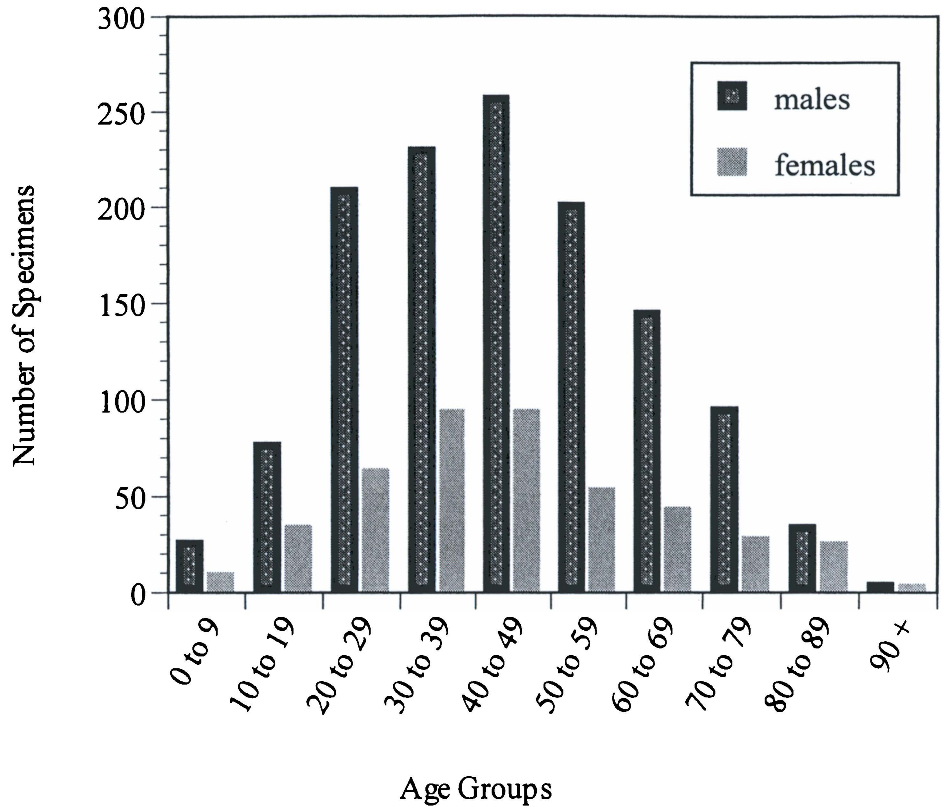

Figure 4.3 Age Profile of Hyoid Specimens from the Osteopathology Evidentiary Collection.

environment at the Forensic Anthropology Research Facility overseen by the Department of Anthropology. Skeletal elements were processed to remove residual soft tissue and to facilitatc long term curation. Individual skeletons are housed at the Forensic Center in the Department of Anthropology at The University of Tennessee. While individual identities are unknown, age, sex and racial affinity are known for all specimens. Sixty-eight were examined. Of these, 56 or 82% are male, and 12 or 18% are female. Ninety-one (62) of decedents are White and 9% (6) are Black (see Table 4.1). Individuals range in age from 25 years to 101 years with a mean age of 61.3 years (64.3 years for females and 60.5 for males). Figure 4.4 illustrates an age profile of specimens used from this skeletal collection. Appendix A provides a listing of all specimens.

William M. Bass Forensic Osteological Collection

This component of the sample is derived from actual casework through the Forensic Anthropology Center. Included in this portion of the sample are specimens collected at autopsy and examined in consultation with pathologists

Table 4.1 Demographics of the William M. Bass Donated Skeletal Collection Hyoid Specimens.

ANCESTRY	***SEX***		***Totals***
	Males	***Females***	
White	51	11	62
Black	5	1	6
Totals	56	12	68

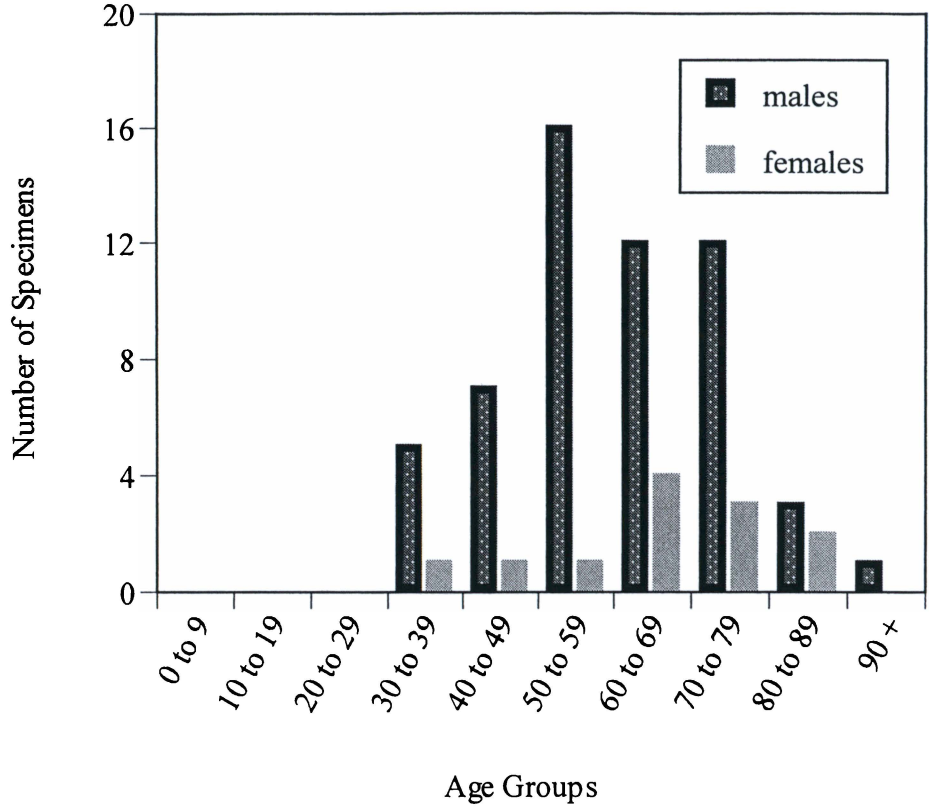

Figure 4.4 Age Profile of the William M. Bass Donated Skeletal Collection Hyoid Specimens.

At The University of Tennessee Medical Center's Regional Forensic Center. Hyoids were removed enmass by careful dissection of the tongue muscles and the inferior musculature following the procedure as described by Wetli et al. (1988). Following examination by the pathologist, each hyoid was dissected from the other laryngeal structures. Remaining soft tissues were removed. Although the William M. Bass Forensic Osteological Collection includes remains recovered over the last thirty years, useable specimens were limited to only those individuals for whom age, sex, and ancestry are known. A total of 24 skeletonized hyoids were examined from the collection of which 16 (67%) are males and 8 (33%) females. Twenty-one are White and 3 are Black (see Table 4.2). Ages range from 18 to 87 years, with mean ages of 40 and 45 years for males and females, respectively. The pooled sample has a mean age of 41 years. See Figure 4.5 for an age profile of this portion of the sample. See also Appendix A for a listing of all specimens.

Sample summary

A total of 1814 skeletonized hyoids were examined for this study. Seventy-five percent or 1350 are male and 464, or 25%, are female. Whites represent 94% (1,716) of the sample. Eighty-four (5%) are Black. One Asian,

Table 4.2 Demographics of Hyoid Specimens from the William M. Bass Forensic Osteological Collection

ANCESTRY	***SEX***		***Totals***
	Males	***Females***	
White	14	7	21
Black	2	1	3
Totals	16	8	24

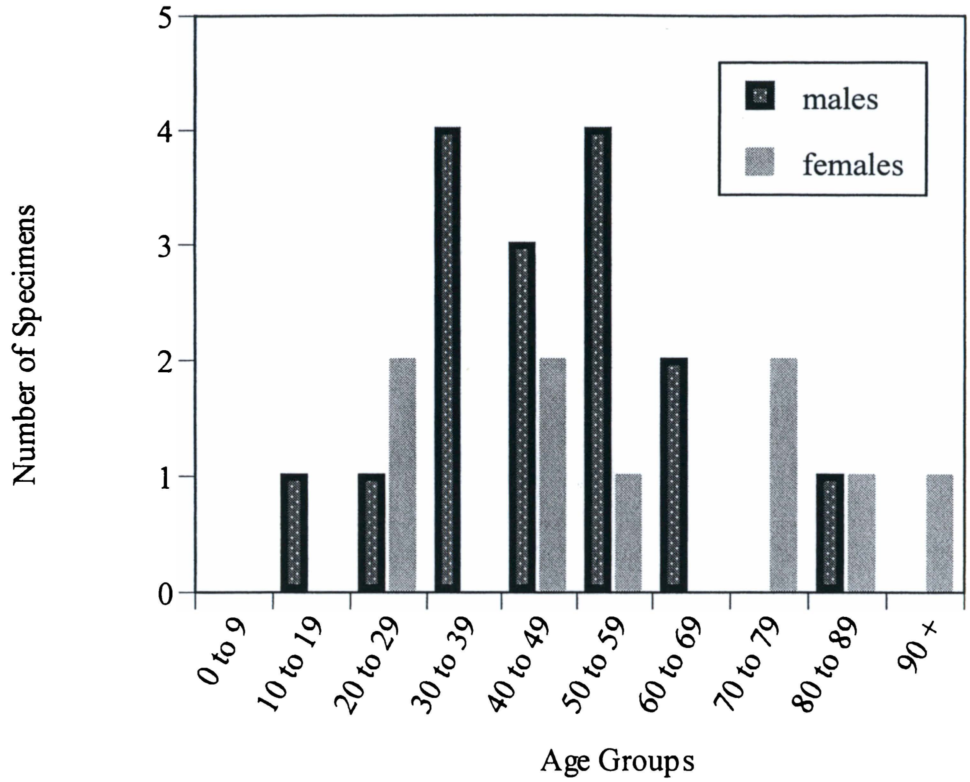

Figure 4.5 Age Profile of the William M. Bass Forensic Osteological Collection Hyoid Specimens.

10 Hispanic, and 3 Native American specimens combined represent less than one percent of the entire sample (see Figure 4.6). Ages for the entire sample range from 2.5 months to 101 years, with a mean age of 44.55 years (see Figure 4.7).

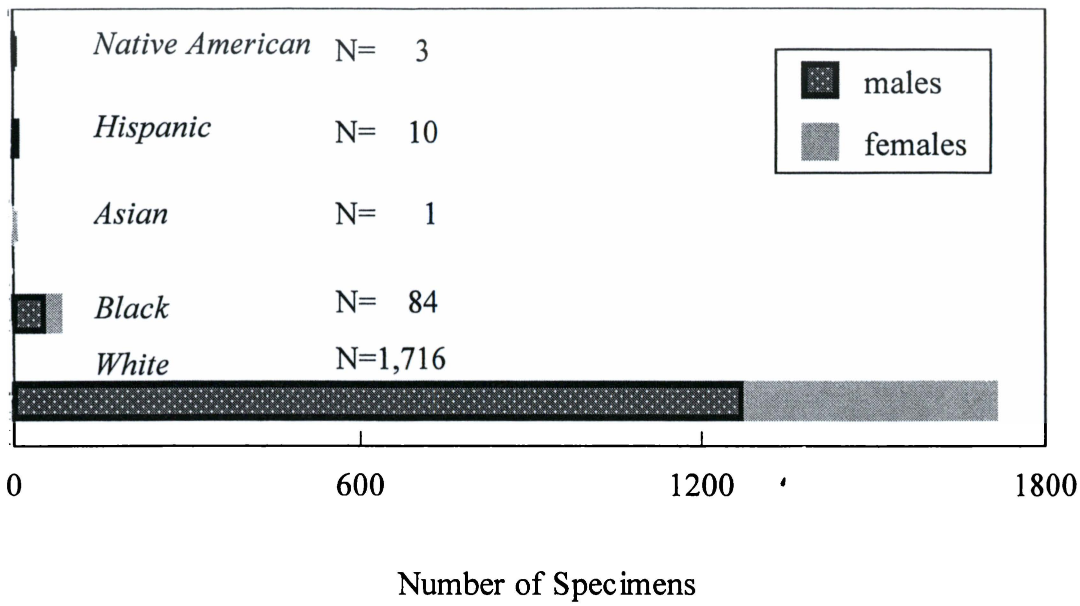

Figure 4.6 Demographics of Combined Sample of Hyoids.

Metric examination

Five measurements were performed on skeletonized hyoid elements. The suite of measurements was designed to reflect the shape and size of the element across three dimensions. The set of measurements were designed to replicate those utilized by other researchers (see for example Komenda and Cerny, 1990; Guilbeau, 1992; Miller et al, 1998). However, given the condition of the specimen, it was not always possible to perform all measurements. These

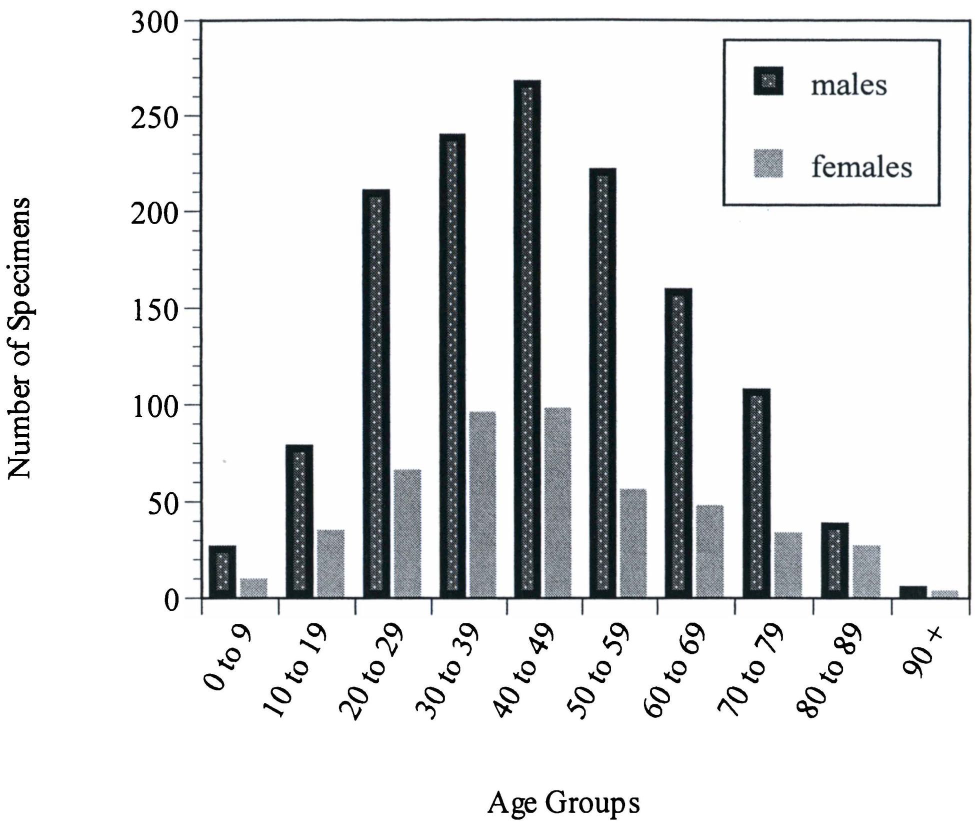

Figure 4.7 Age Profile of Combined Sample of Hyoids

situations are noted in the measurement descriptions. Specimens were measured using Spi digimax 30-440-2 digital calipers. Measurements were recorded in millimeters to the nearest hundredth. The measurements are as follows:

Body height. (BH)
This is defined as the height of the body along the midline. This measurement is performed by elevating the body and placing the blades of the calipers on the superior and inferior borders of the body. The calipers are held such that the longitudinal axis of the tool is parallel to the anterior surface of the hyoid body. See Figure 4.8.

Body width. (BW)
This value reflects the width along the central axis of the body. The element is positioned on a flat surface with the superior surface upwards. The tips of the caliper blades are placed on the posteriosuperior surface, at the midpoint of the left and right sides of the body. For isolated body elements, the blades are placed on the posteriosuperior margin of the lateral articular surfaces. If the lateral aspects of the hyoid body are not clearly demarcated, the measurement is not collected. See Figure 4.9.

Body thickness. (BT)
This measurement determines the thickness in the anterior posterior plane of the hyoid body taken along the inferior margin at the mid line. The element is held in a position such that the blades of the calipers are on the inferoanterior and inferoposterior aspects. The blades are positioned such that the thickness of the body is reflected and not the concavity of the body. See Figure 4.10.

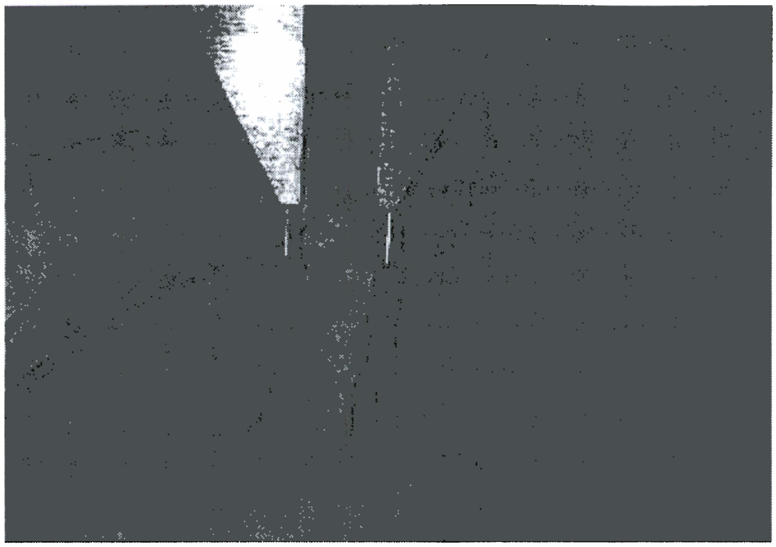

Figure 4.8 Technique for measuring height of hyoid body (BH).

Figure 4.9 Technique for measuring width of hyoid body (BW).

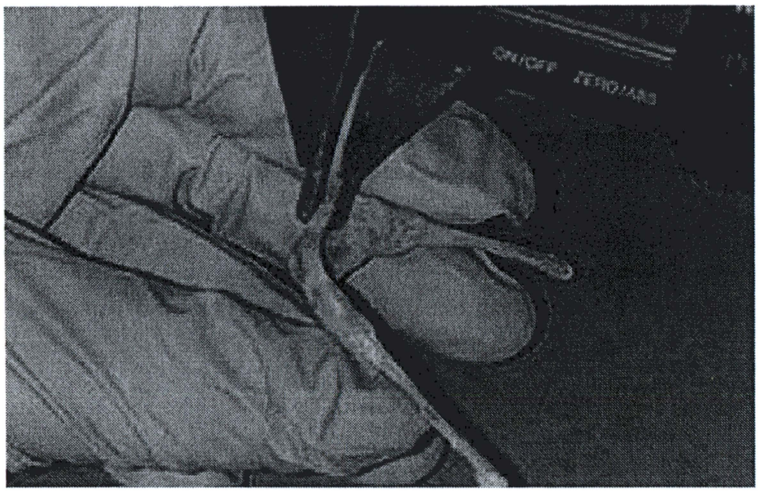

Figure 4.10 Technique for measuring thickness of hyoid body (BT).

Greater horn span. (GHS)
This measurement records the span of the greater horns at their posterior most extension. With the element positioned with the superior surface face down on a flat surface, the blades of the calipers are placed on the lateral aspects of the posterior most projection of the greater horns. See Figure 4.11. In instances where specimens exhibit no union or unilateral union this measurement is not performed. This measurement is not performed if the horns are not intact.

Greater horn posterior distance. (GHD)
This measurement records the distance between the greater horns at their posterior most extension. With the element on a flat surface with the inferior aspect up, the blades of the calipers are placed on the medial aspects of the posterior most projection of the greater horns. See Figure 4.12. In instances where specimens exhibit no union or unilateral union this measurement is not performed. This measurement is not performed if the horns are not intact.

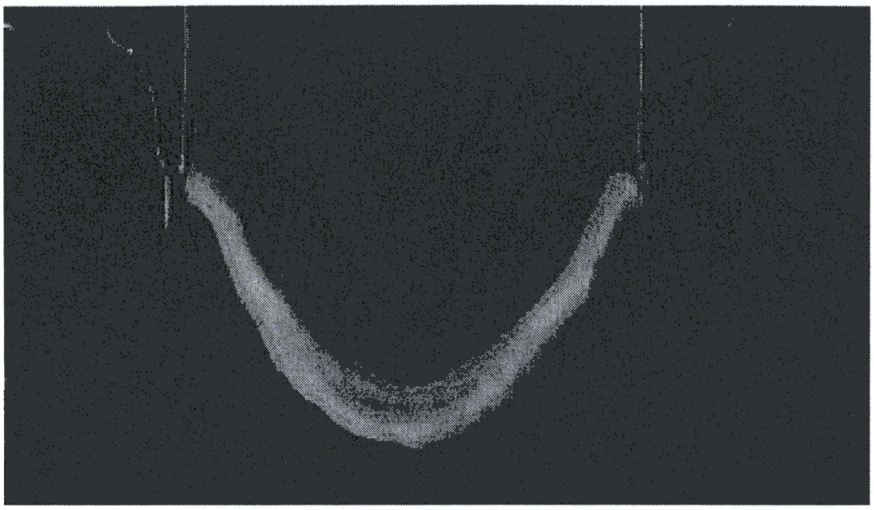

Figure 4.11 Technique for measuring greater horn span (GHS).

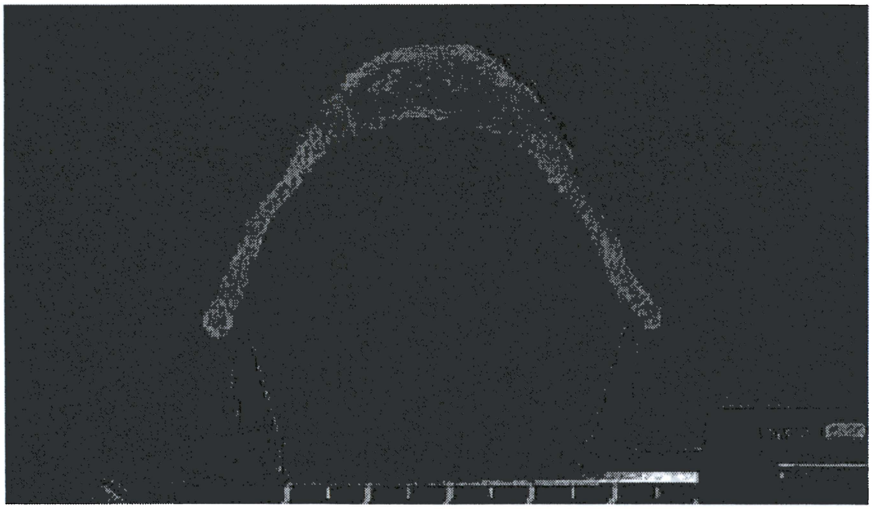

Figure 4.12 Technique for measuring greater horn posterior distance (GHD).

Given the data collected it will be possible to create measurement indices from combinations of measurements to further reflect and investigate hyoid morphology, e.g. the average thickness of the greater horn tips can be calculated given data contained in the span and distance measures of the greater horns.

Visual assessment

The level of union between the body and the greater horn was assessed visually. The condition of fusion was scored based upon visual assessment of the juncture of the body and the greater horn. Left and right sides were evaluated. Initial examination involved determination of the level of union between the body and the greater horn as *open, closed* or *active*. Both the left and right sides were evaluated independently and assigned a numerical code (0, 1, 2) to correspond to the level of union. See Figure 4.13 for a depiction of the fusion levels.

Open was defined as the absence of any bony union between the body and the greater horns (0). A code of (0) was assigned in instances where the greater horns were absent. *Closed* (2) was defined as the complete union between the body and the greater horn absent any margin or evidence of a separation between the body and the greater horns (2). *Active* (1) was defined as the ongoing process of fusion between the elements as evidenced by some level of bony union between the body and greater horns.

Figure 4.13 Levels of fusion identified on hyoid specimens. Left: open (0) on both left and right sides. Middle: active (1) on left. Right: closed (2) on both left and right sides.

The designation of fusion as *active* warranted a further evaluation to investigate whether patterns of fusion exist. For each side assigned a (1) (*active* fusion) a more intensive investigation was performed. The juncture between the lateral margins of the body and the greater horn was assessed as if it were cross-sectioned. This conceptual surface was divided into quadrants numbered 1-4; arranged clockwise on the right side and counterclockwise on the left side. (See Figure 4.14). The superior posterior quadrant surface is (1), the inferior posterior quadrant surface is (2), the inferior anterior quadrant surface is (3) and the superior anterior quadrant surface is (4). Only the degree of fusion evident on the outer surface was assessed.

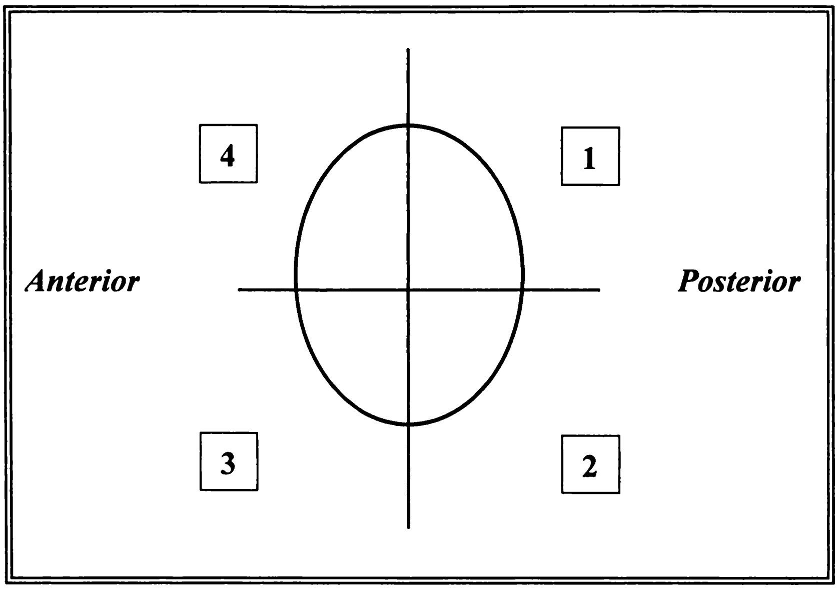

Figure 4.14 Schematic of quadrant system utilized in estimating degree of fusion as applied to the right side.

The degree of fusion across the surface of each these quadrants was assessed as *open*, *trace* or *complete*. *Open* was defined as the absence of union of the body and greater horn across the surface; coded (1). The visible location of union of the two sides indicated by a prominent fusion line across the surface was defined as *trace* and was coded (2). Union of the two elements with no visible evidence of two separate structures was defined as *complete* fusion and coded (3). The degree of fusion was assessed for all four quadrant surfaces on each side with active fusion. See Appendix C (L1, L2, L3, L4 and R1, R2, R3, R4).

Statistical Interpretation

Data were subjected to statistical analysis to facilitate an objective assessment of patterns of development. Metric and coded data were analyzed separately. Data were assessed using SPSS software version 10.1 (SPSS Inc., 1996 and SPSS Inc., 1999). Prior to analysis, all data were assessed for normalcy. Metric data were examined to discern whether and to what degree, age, ancestry and sex influence hyoid dimensions. Descriptive statistics were performed on all variables to illuminate any trends with regard to size. Plots were produced using Deltagraph.

To assess whether size or shape differences exist between males and females, t-tests were conducted. This test compares the means of two sample populations on a particular variable to assess whether the means differ greatly from one another. The tests used in this study were based on the assumption of unequal variances between the sample populations. These were performed on males greater than 19 years of age and females greater than 15 years of age. The values, 19 and 15, reflect the ages at which growth ceases for males and females, respectively. This was demonstrated by a linear response and plateau function constructed on body height values. This non linear function of growth models development as beginning at time 0 (intercept) and progressing at a particular rate (slope) and reaching a level of no further increase in size, i.e., cessation of growth (plateau) (see Konigsberg et al., 1990).

The data were further investigated to determine whether the stage of fusion, open, active or closed, is associated with sex and or age. Subsequent examination will address whether fusion between the body and the greater horn follows a pattern. Data were initially examined using Nphases to determine whether the stages of open, active and closed are delineated developmental stages. Fusion scores were subjected to examination using NPhases, to determine whether the use of three stages of fusion estimation is sound. Transitional analysis provides a means to consider whether stages or events are identifiable in that they are delineated and that a subject progresses through stages in an predictable manner. This transitional analysis program demonstrates whether developmental, or degenerative stages, are statistically significant (see Konigsberg and Herrmann, 2002; Boldsen et al., 2002). The output indicates the average age and standard deviation of transition between developmental stages. Three models may be produced for cumulative ages with a common standard deviation for log linear values with a common standard deviation and cumulative ages with individual standard deviations.

Descriptive statistics were performed to generate information regarding frequency of fusion with respect to both age and sex. Subsequently, the potential influence of sex and age on the level of fusion, i.e., open, closed, or active, was assessed using SPSS version 10.1. To further investigate aspects of fusion, chi-squared tests of independence were performed to assess whether the level of fusion on one side is contingent upon the level of fusion on the opposing side of an element. These data were considered in terms of sex and age group of specimens. Ancestry was pooled for all aspects of fusion analyses. To improve sample sizes for several statistical tests, individuals in the upper three age groups (90+, 80-89, and 70-79) were combined into a single age group: 70+.

In order to investigate the relationships between fusion condition and age, a loglinear model was employed. Such an analysis enables the examination of multiple dimensions of categorical measures including main effects and all possible interactions. Associations were tested for all main effects (LHF, RHF, and age group), as well as all two way interactions and the three way interactions of age group and fusion status for the left and right horns.

Additional chi squared tests of independence were conducted to determine whether fusion between the hyoid body and greater horns follows a developmental pattern; to assess whether the degree of fusion in a particular quadrant is contingent upon the degree of fusion in adjacent quadrants. Two way cross tabulation tables were generated. Left and right sides were investigated independently. Four hundred thirty-three left sides were assessed and 425 right sides were tested. Sex, age and ancestry were pooled for this analysis.

Both descriptive and multivariate statistical tests were performed to thoroughly assess and reflect morphological variation to illuminate developmental and degenerative patterns and to investigate the variables which are correlated with such conditions.

Chapter V

Results

Introduction

Examination of 1,814 hyoids provided data concerning two primary aspects of growth and development; 1) overall size and shape dimensions and 2) fusion sequence between the body and greater horns. The metric data were analyzed to address these parameters. Descriptive statistics and multivariate analyses were conducted. The data comprise a representative sample of male and females across all ages. However, equal representation across ancestral groups is not possible. Prior to detailed statistical analysis, measures of the height, width, and thickness of the hyoid body are presented, BH, BW, and BT, respectively. Figure 5.1 illustrates the mean values for the three measurements of the hyoid body separated by ancestry. Greater horn span (GHS) and greater horn distance (GHD) were not evaluated as insufficient data were collected to accurately compare these dimensions by ancestry. The condition of the single specimen of Asian ancestry did not permit collection of the body width variable. Hence, no data is available for this measure.

Differences between these ancestral groups appear insignificant. Although a disparity exists between each group in number of specimens and the

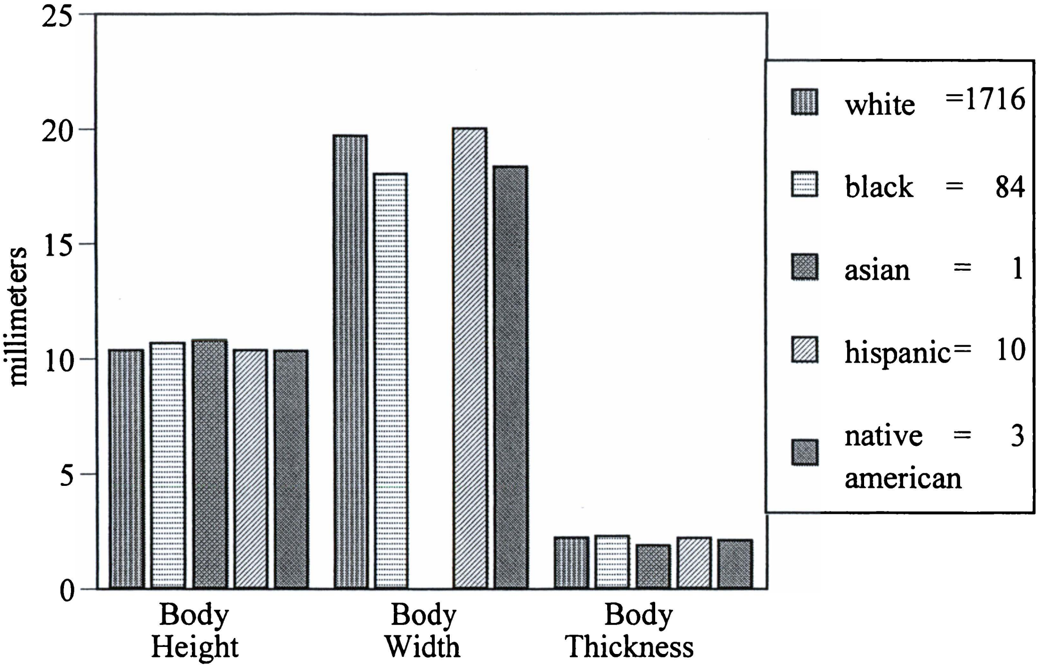

Figure 5.1 Mean size of three hyoid body measures by ancestry. Sex and age pooled.

age and sex composition, the mean values do not indicate differences exist between ancestral groups. Given this, ancestry was combined in all further evaluations.

Size and Shape

The suite of measurements collected was designed to reflect both size and shape of the hyoid bone. Specimens were examined to assess whether metric differences exist between sexes and age groups. Table 5.1 provides

Table 5.1 Mean and standard deviation of body and horn measures (in mm) by age group. Values are pooled by sex and ancestry.

Age	***N***	***Body Height***	***Body Width***	***Body Thickness***	***Greater Horn Span***	***Greater Horn Distance***
0-9	35	6.74 1.12	9.37 2.12	1.63 0.33		
10-19	112	9.86 1.48	16.25 2.28	2.02 0.43		
20-29	249	10.3 1.34	19.3 2.45	2.13 0.48	44.6 5.55	38.46 5.57
30-39	334	10.34 1.39	20.02 2.47	2.16 0.46	45.07 5.86	38.18 5.69
40-49	364	10.39 1.50	20.25 2.40	2.17 0.49	46.82 6.33	39.37 6.22
50-59	31	10.51 1.29	20.80 2.51	2.25 0.51	45.31 6.02	37.88 5.79
60-69	206	10.73 1.48	20.83 2.47	2.27 0.522	48.6 6.87	40.88 6.65
70-79	140	10.62 1.61	20.91 2.65	2.23 0.48	47.56 4.83	39.58 4.61
80-89	64	10.34 1.41	19.64 3.07	2.06 0.42	46.49 6.21	39.49 5.81
90+	9	9.42 0.87	19.51 4.05	2.35 0.23	46.13 1.95	39.9 2.17

group mean values and one standard deviation score for body height (BH), body width (BW), body thickness (BT), greater horn span (GHS), and greater horn distance (GHD). It was not possible to collect GHS and GHD values for specimens in the age groups 0-9 and 10-19 given that no union existed between the body and the greater horns.

Tests of normality were performed to illustrate whether the data are normally distributed. Shaprio-Wilk's values indicate all five measures are normally distributed. For each measurement of the hyoid body, little difference in size is apparent between age groups beyond the second decade of life. However, each of these variables was independently, and then collectively, subjected to more stringent analysis. Correlations between measures and demographic variables were also assessed. Pearson correlations reflect the magnitude and direction of a relationship between two variables with scores of 1 and –1 indicating strong associations between variables. Although a strong association occurs between the GHD and GHS variables (r=.937), this is due to the fact that the measurements are partially overlapping (see Chapter 4). No other strong relationships are evident as other correlation values are less than 0.3.

Body Height

Figure 5.2 illustrates a scatterplot of body height measures for males and females. Individuals in the first decade of life demonstrate a lesser body height

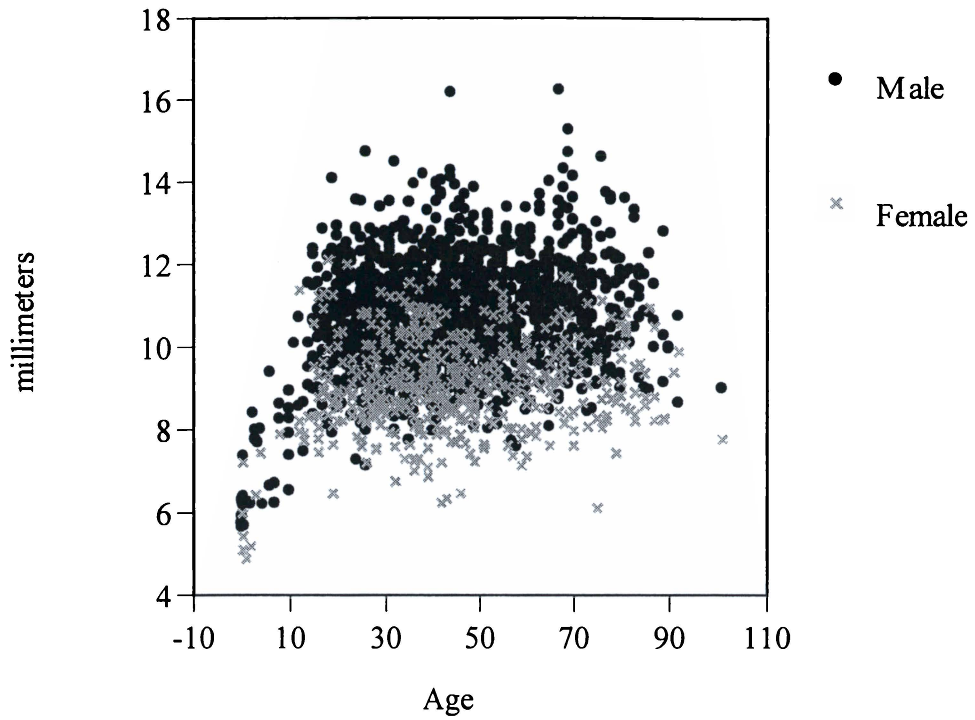

Figure 5.2 Body height in millimeters by age group. Ancestry is pooled.

than all other age groups. A gradual increase in height of the body continues from the first through the third decade followed by a plateau throughout the middle and latter decades.

Table 5.2 provides descriptive statistics for body height separated by sex. Males older than or equal to 19 years of age and females older than or equal to 15years of age are represented. Males on average display a slightly larger measure for the height of the hyoid body. The largest measure of body height (16.22 mm) was recorded on a specimen from the seventh decade of life, a 67

Table 5.2 Hyoid body height (in mm) by sex. Mean, minimum, maximum, and one standard deviation with pooled ages; males ≥ 19 years and females ≥ 15 years.

Sex	*N*	*Mean*	*Maximum*	*Minimum*	*Standard Deviation*
Male	1,261	10.86	16.22	7.12	1.27
Female	448	9.18	9.18	6.11	1.09

year old white male. The smallest measure of body height (4.88 mm) was recorded from a specimen in the first year of life (1 year old white female). There are significant differences between the mean value for males and the mean value for females as demonstrated by the t-test statistic (t stat=26.69 df=906, t=1.96).

Figure 5.3, a box and whisker plot, illustrates the maximum, minimum, and standard deviation for body height measurement by age group. Sexes are pooled. This depiction reflects the height of the hyoid body as noticeably shorter during the first decade of life. The second through the ninth decade reflect little variation in mean body height. A decreased height of the hyoid body characterizes specimens from the 90+ years age group.

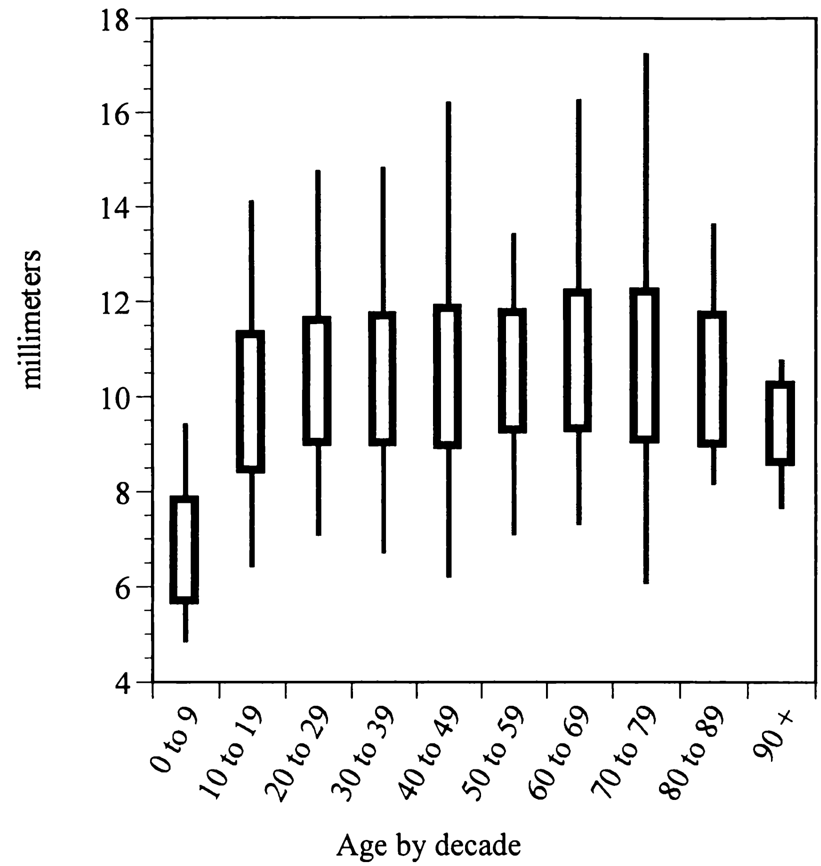

Figure 5.3 Maximum, minimum, and standard deviation (in mm) for Body Height by age group. Sex is pooled.

Body Width

A scatterplot of body width by sex is presented in Figure 5.4. Ancestry is pooled. With a few exceptions, individuals in the first two decades of life demonstrate a lesser body width than all other age groups. Beyond this time, there appears to be less variation in the width of the hyoid body. There is no

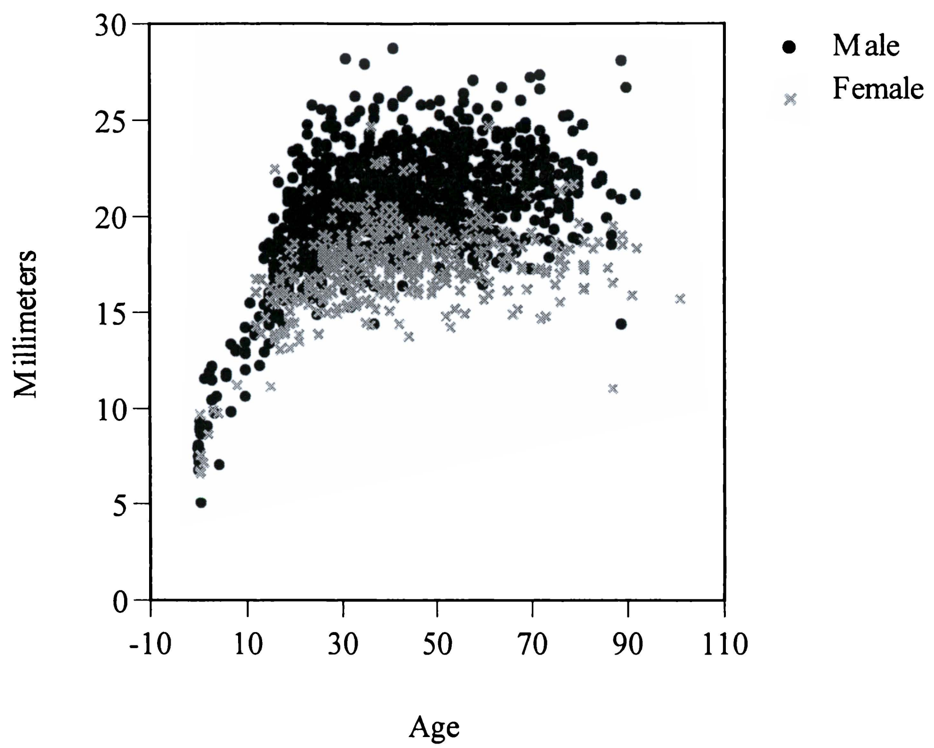

Figure 5.4 Body width in millimeters by age group. Ancestry is pooled.

apparent difference in width of the hyoid body between male and female specimens.

Table 5.3 provides mean, maximum, minimum, and standard deviation for body width measures on males and females. Ages are pooled; males $\geq$ 19 years and females $\geq$ 15 years. On average, females (17.59 mm), exhibit a narrower body than do males (21.02 mm). Standard deviation values are 2.2 and 1.96 for females and males, respectively. The smallest, and also the largest,

Table 5.3 Hyoid body width (in mm) by sex. Mean, minimum, maximum, and one standard deviation with pooled ages; males ≥ 19 years and females ≥ 15 years.

Sex	*N*	*Mean*	*Maximum*	*Minimum*	*Standard Deviation*
Male	936	21.02	28.65	14.32	2.20
Female	359	17.59	24.71	11.02	1.96

body width measures were recorded on males. The smallest width (4.98 mm) was recorded on an 8 month old white male with the largest width (28.65mm) measured on a specimen from the fifth decade of life, a 41 year old white male. T-tests on the two samples, assuming unequal variances, indicate that significant differences exist between the mean body width for males and the mean body width for females (t-stat=27.17, df=724 critical value=1.96).

Figure 5.5 illustrates a box and whiskers plot of maximum and minimum values and standard deviations for hyoid body width by age group. Sexes are pooled. Although the mean value is lowest for specimens in the first decade of life, an increase in mean width of the hyoid body is apparent during the second decade. This trend continues into the third decade. During the middle years (age groups 40-49, 50-59, 60-69, and 70-79) there is little apparent variation in mean width of the hyoid body. Specimens from the 80-89 age group a lower

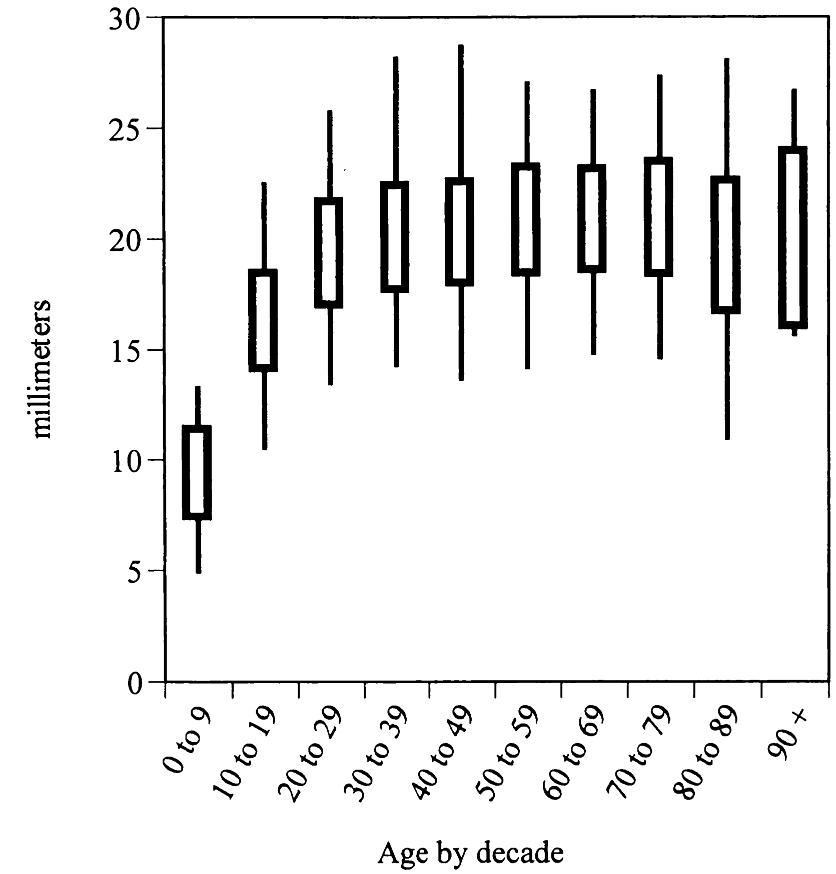

Figure 5.5 Maximum, minimum, and standard deviation for Body Width by age group. Sex is pooled.

demonstrate mean value for width of the hyoid body compared to specimens from the preceding decade, though the older age group exhibits a wider range from maximum to minimum values. The collection of specimens from the 90+ age group demonstrate a high standard deviation.

Body Thickness

Values of hyoid body thickness by age and sex are graphically presented in Figure 5.6. Ancestry is pooled. The lowest measurement values were collected on specimens from age groups beyond the second decade of life. Both the low and high values were collected on male specimens. The lowest value (0.72 mm) was recorded on a white male 36 years of age. The highest (4.44 mm) was recorded on a 59 year old white male (see Table 5.4). The range between maximum and minimum values for thickness of the hyoid body demonstrates a high degree of variation of this variable. T-test results demonstrate that significant differences exist between the mean body thickness values for males and females. Males, on average, are thicker than females (t-stat=14.29, df=959, critical value= 1.96).

Greater Horn Span

Figure 5.7 illustrates the relationship between the span of the greater horns and age for both males and females. The nature of this measurement prohibited collection in the youngest age groups due to the condition of these specimens. The scatterplot reflects the general range in values for this measure and demonstrates that the hyoid varies less across this dimension within the older and younger age groups. Males demonstrate a greater degree of variation than do females. The largest (71.22 mm) and the smallest (16.48 mm) values of GHS were collected on male specimens (see Table 5.5). Both of these

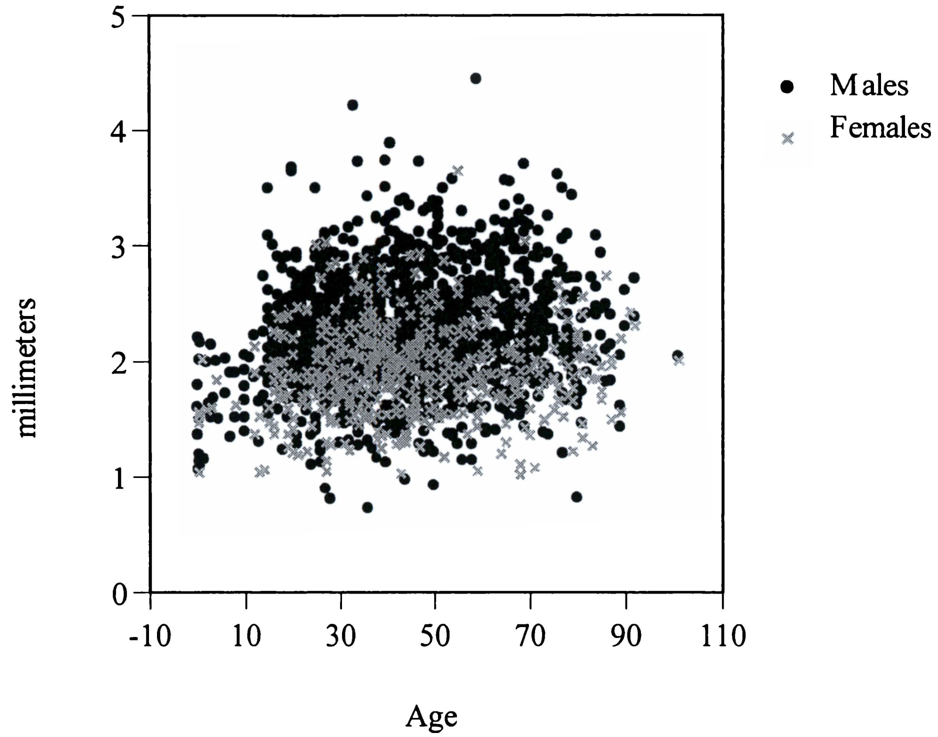

Figure 5.6 Body thickness in millimeters by age. Ancestry is pooled.

Table 5.4 Hyoid body thickness (in mm) by sex. Mean, minimum, maximum, and one standard deviation with pooled ages; males ≥ 19 years and females ≥ 15 years.

Sex	***N***	***Mean***	***Maximum***	***Minimum***	***Standard Deviation***
Male	1258	2.27	4.44	.72	.49
Female	448	1.94	3.65	1.02	.4

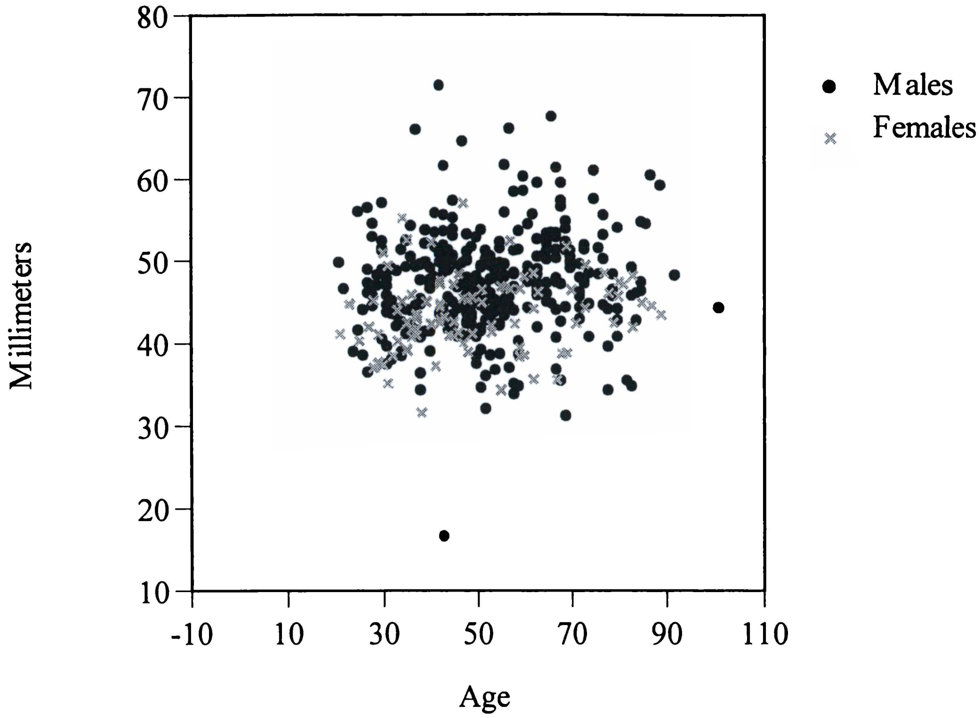

Figure 5.7 Greater Horn Span in millimeters by age. Ancestry is pooled.

Table 5.5 Greater Horn span (in mm) by sex. Mean, Minimum, Maximum, and one standard deviation with pooled ages.

Sex	***N***	***Mean***	***Maximum***	***Minimum***	***Standard Deviation***
Male	330	47.23	71.22	16.48	6.29
Female	97	43.46	56.97	31.57	4.62

measurements were collected on specimens from the fifth decade of life, a 42 White male and a 43 year old Black male, respectively. Males exhibit on average larger values for the span of the greater horns than do females as indicated by a t-test assuming unequal variances (t-stat=6.46, df=211, critical value= 1.97).

Greater Horn Distance

The trends noted for the span of the greater horns are similar to those for the measurement of the interior distance between the posterior aspects of the greater horns (GHD). Figure 5.8 is a scatterplot of the distance between the posterior projections of the greater horns (GHD). Males exhibit a greater degree of variation on the measurement than do females. The minimum and maximum values were recorded on males. The minimum value (9.8 mm) was recorded on a Black male, 43 years of age. The maximum value (63.63 mm) was recorded on a 42 year old White male (see Table 5.6). There are significant differences in the mean values for this dimension between males and females. Males exhibit on average larger values for the distance between the greater horns in comparison to females as indicated by a t-test assuming unequal variances (t-stat=6.18, df=215, critical value= 1.97).

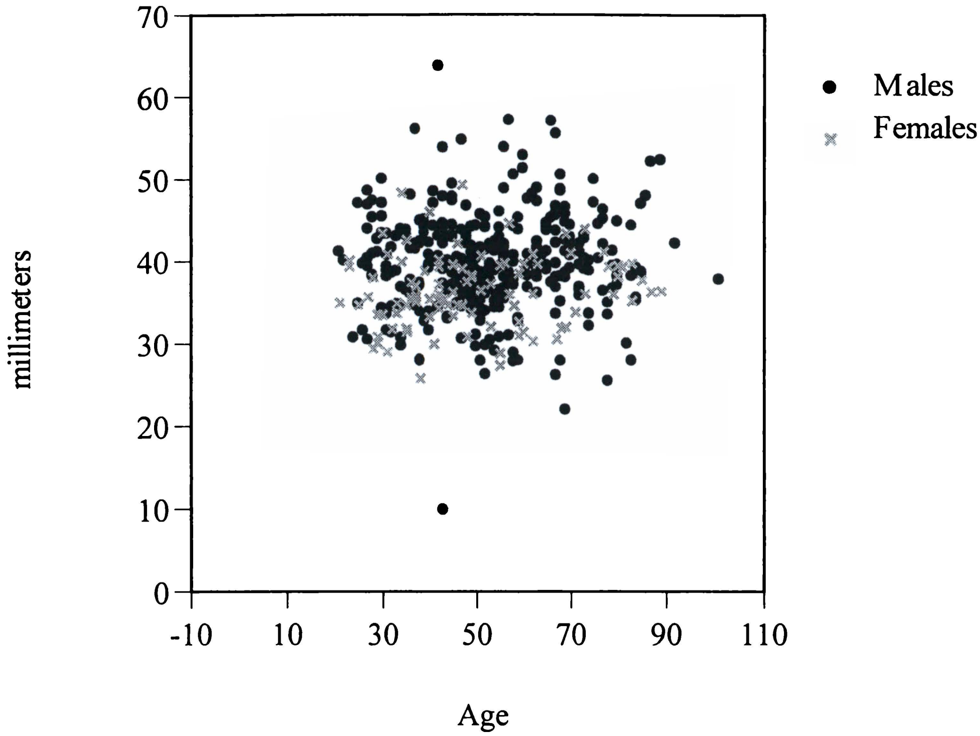

Figure 5.8 Greater Horn Distance in millimeters by age. Ancestry is pooled.

Table 5.6 Greater Horn distance (in mm) by sex. Mean, Minimum, Maximum, and one standard deviation with pooled ages.

Sex	*N*	*Mean*	*Maximum*	*Minimum*	*Standard Deviation*
Male	334	39.77	63.63	9.8	6.12
Female	97	36.36	49.25	25.77	4.4

Mean Greater Horn Tip thickness

To further investigate the aspects of the greater horn, the mean thickness of the tips of the greater horns were calculated (MTT). This value was calculated for specimens with both GHS and GHD measures. It reflects the mean thickness of the posterior aspect of the greater horn for each specimen. A scatterplot of this calculated variable is provided in Figure 5.9. It was not possible to calculate this measure for specimens from the youngest two age groups.

Table 5.7 provides mean, maximum, minimum and one standard deviation for specimens by sex. The maximum (5.9 mm) and minimum (0.61 mm) thickness for the posterior portion of the greater horns were found on white males 70 and 80 years of age, respectively. T-tests indicate that there are significant differences in the mean values between the sexes. On average, males exhibit larger mean tip thickness than do females (t-stat=2.47, df=204, critical value=1.97).

Size and shape descriptive statistics summary

Descriptive statistics for the five measures BH, BW, BT, GHS, and GHD, and the calculated value MTT, indicate that there are several trends for these size measurements with regard to age and sex of the specimens. For all variables, males on average exhibit larger values in comparison to females.

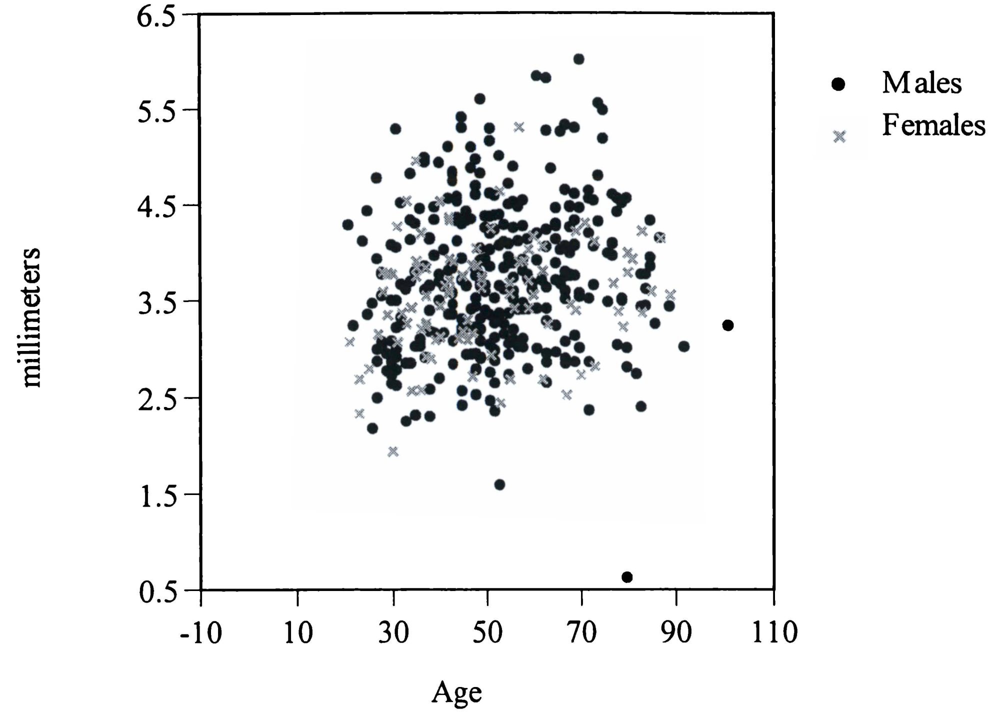

Figure 5.9 Mean greater horn posterior tip thickness in millimeters by age. Ancestry is pooled.

Table 5.7 Mean, Minimum, Maximum, and standard deviation in mm for Mean Tip Thickness by sex. Ages are pooled; males ≥ 19 years and females ≥ 15 years.

Sex	***N***	***Mean***	***Maximum***	***Minimum***	***Standard Deviation***
Males	329	3.73	5.9	.61	.76
Females	97	3.55	5.3	1.94	.58

Fusion

The Nphases transitional analytical program indicated that the three stages of fusion (open, active, and closed) are verifiable. Using age data for the population sample, the mean age of transition from an open to an active stage occurred at 53.9 years with a standard deviation of 37.29 and at 55.6 years with a standard deviation of 37.17 for left and right sides respectively. The mean age of transition from an active stage to a closed stage was calculated as 98.53 years, (standard deviation= 50.76) and 93.80 years, (standard deviation= 46.61) for the right and left sides respectively.

Examination of males and females independently using Nphase did not demonstrate any significant differences between sexes. The mean age of transition for males from an open to an active stage occurred at 52.55 years with a standard deviation of 36.91 and at 91.39 years with a standard deviation of 48.87 from an active to a closed stage. Female specimens, exhibit transition from an open to an active stage at 57.95 years with a standard deviation of 37.96 and at 107.95 years with a standard deviation of 54.91 for transition from active to closed.

Descriptive statistics were generated to demonstrate the frequency of fusion conditions with regards to age and sex. Table 5.8 provides counts for the incidence of bilateral fusion for both males and females by age groups. Percentage values reflect the proportion of fusion against the total sample population for that sex and age group.

Table 5.8 Bilateral occurrence of fusion degree by age and sex. Percentages are calculated on entire sample population.

Age	***Male***				***Female***			
	N	***Open***	***Active***	***Fused***	***N***	***Open***	***Active***	***Fused***
0-9	26 100%	26 100%	0	0	9 100%	9 100%	0	0
10-19	77 99%	77 99%	0	0	34 100%	34 100%	0	0
20-29	181 86%	165 79%	9 4%	7 3%	59 91%	51 78%	6 9%	2 3%
30-39	176 74%	130 54%	26 11%	20 8%	72 76%	52 55%	12 13%	8 8%
40-49	178 67%	101 38%	38 14%	39 15%	69 71%	51 53%	11 11%	7 7%
50-59	151 68%	83 38%	33 15%	35 16%	39 71%	26 47%	7 13%	6 11%
60-69	107 67%	46 29%	30 19%	31 19%	34 72%	17 36%	11 23%	6 13%
70+	110 73%	40 27%	29 19%	41 27%	44 71%	20 32%	12 8%	12 8%
Total	1006 75%	668 49%	165 12%	173 13%	360 78%	260 56%	59 13%	41 8%

Fusion occurs bilaterally for 75% of the males and 78% of the females. Among all males, approximately half (49%) of the population exhibits bilateral non fusion. More so, among females bilateral non fusion occurs in 56% of the sample population. Among females, bilateral complete fusion occurs in less than 10% of the age group populations, with the exception of the sixth and seventh decades where bilateral fusion occurs for 11% and 13% of the age group populations. Among male specimens the percentage of bilateral fusion increases steadily with age from a low of 3% for specimens in the third decade of life, to a high of 27% in the 70+ age group. Bilateral fusion occurs in 13% and 8% of the total sample population for males and females, respectively. Among males, the rates of active bilateral fusion are compatible with those for bilateral fusion, 12% and 13%, respectively overall. During the third and fourth decades the percentage of active is greater than fused. This trend is reversed in the 70+ age group where the number of fused specimens is much greater than the number of active specimens. Among females overall incidence of bilateral active is greater than bilateral fused for all age groups, 13% and 8%, respectively. This trend is apparent for all female age groups. These data additionally serve to reflect the incidence of unilateral fusion conditions for the sample population. Unilateral fusion occurs in 25% of the male specimens and in 22% of the female specimens.

The fusion condition for each side of the hyoid was assessed for age groups. Figure 5.10 and Figure 5.11 illustrate the frequency of fusion

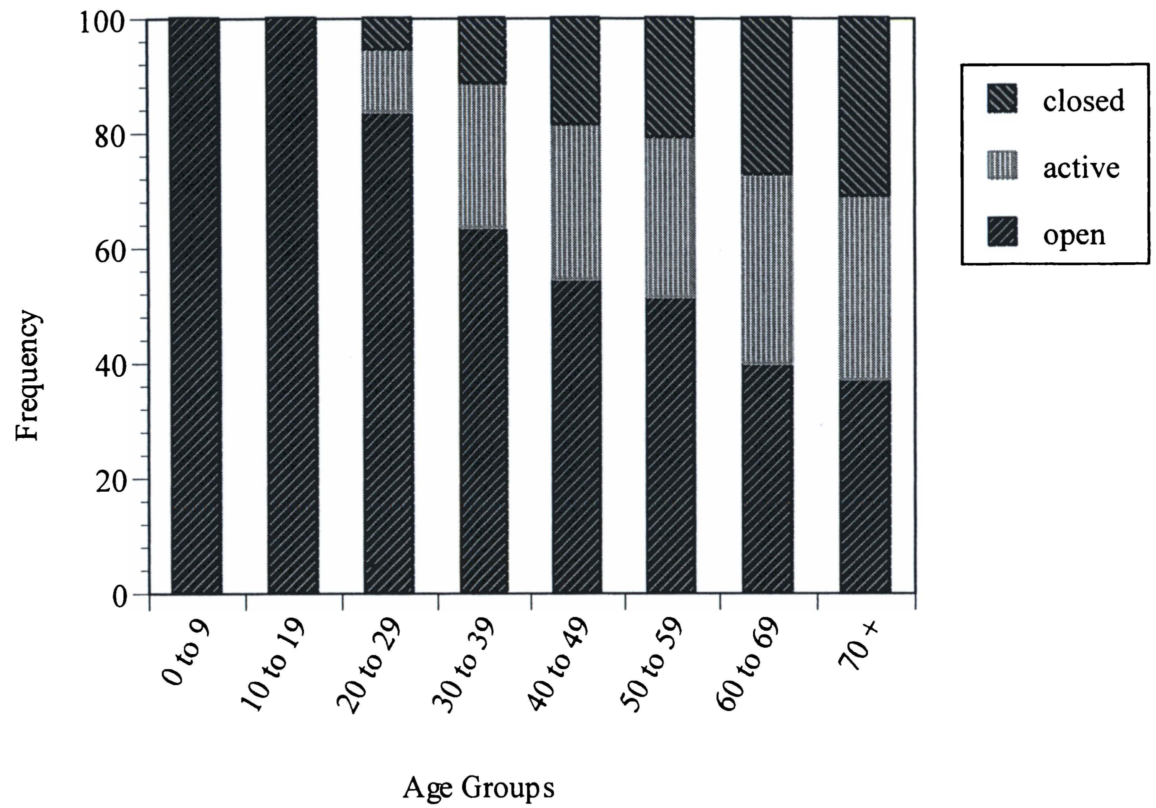

Figure 5.10 Incidence of fusion at right side by age group. Sex is pooled.

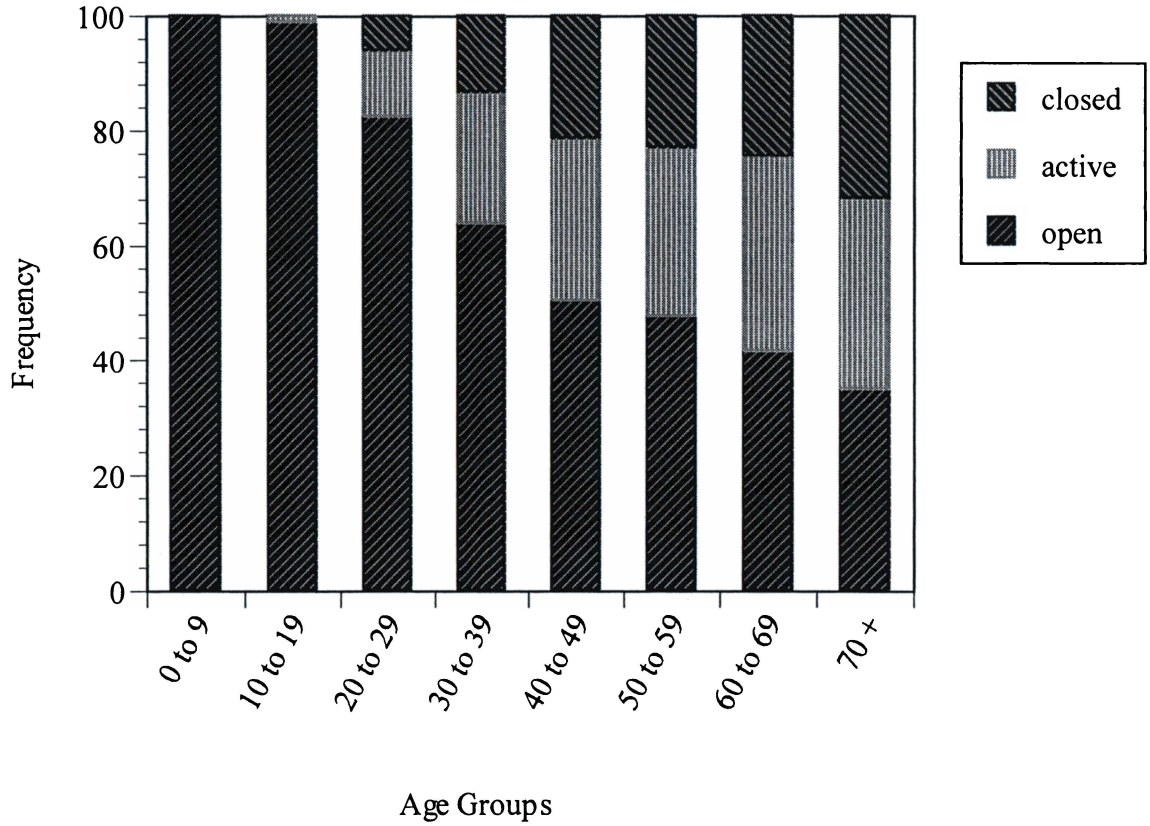

Figure 5.11 Incidence of fusion on left side by age group

conditions, i.e. open, active, closed, for the sample populations, right side data and left side data, respectively . Sex is pooled. With the exception of a single specimen, individuals in the 0-9 and 10-19 age groups do not exhibit fusion between the body and greater horns. Figure 5.11 illustrates the single case of active fusion occurred on the left side. This is a white male of 19 years.

Similar frequencies of fusion level both within and between age groups are apparent for both the left side and the right side of the hyoid body. A decrease in the incidence of non fusion (open) occurs with increasing age of specimens. This trend begins during the third decade of life, and gradually continues until the seventh decade. However, the percentage of non fused specimens per age group is never less than thirty-five percent. Throughout the third through the eighth decade, a steady increase in the frequency of active and complete fusion (closed) occurs, while the frequency of non fusion (open) decreases. A dramatic increase in the incidence of active and closed fusion is apparent when comparing the frequencies noted for the 20-29 age group to those noted for the 30-39 age group. During this time it appears the frequency of both of these fusion conditions nearly double. An increase in the incidence of both active fusion and complete fusion continues through the sixth decade. Visual inspection of the last two age groups (60-69 and 70+) demonstrates an equitable representation of the three levels of fusion.

Table 5.9 presents counts of incidence of fusion for males and females on both left and right sides. Age is pooled. Among females, a total of 260

Table 5.9 Crosstabulation of LHF and RHF by sex. Age and ancestry is Pooled.

Sex			***Right Horn Fusion***			***Totals***
			open	***active***	***closed***	
Males	***Left Horn Fusion***	***open***	668 454.7	93 182.3	13* 137**	*774*
		active	105 189.7	165 76.1	53 57.2	323
		closed	20 148.6	60 59.6	173 44.8	253
	Totals		793	318	239	1350
Females	***Left Horn Fusion***	***open***	260 184.4	28 66.6	1 38	289
		active	33 70.8	59 25.6	19 14.6	111
		closed	3 40.8	20 14.8	41 8.4	64
	Totals		296	107	61	464

* Observed
** Expected

specimens were open on both left and right sides, 59 were active on both left and right sides, and 41 were closed on both sides. The females are bilaterally symmetric across 77% of the collection. Among males, 668 (50%) were open on both left and right sides, 165 (12%) were active on both left and right sides and 173 (13%) were closed on both left and right sides. The male sample population is 75 % bilaterally symmetric.

The chi square test of independence demonstrates that a dependency exists between the fusion condition of the left and right sides of the hyoid body for both sexes. As exhibited in Table 5.9, right and left horn fusion status are identical, much more frequency than would be expected if the two processes were independent. Pearson chi-square for females is 317.684 df=4, and for males it is 876.489 df=4. The chi square test of independence is significant and indicates that there is a relationship between fusion condition on the left side and fusion condition on the right side.

For males who exhibit open fusion on the left horn, they are 7 times as more likely to be open on the right than to be active on the right. Further, this same group is over fifty times more likely to be open on the right than to be closed on the right side. These general patterns are also true for females. Females with non fusion on the left demonstrate 9 times greater likelihood of being open versus active on right and over 200 times greater likelihood of being open on right than being closed. For specimens coded as closed on the left, males exhibit a 3 times greater likelihood of being closed on the right than being active and a 9 times greater chance of being closed than being open. Females coded as closed on the left, are twice as likely to be closed on the right than to be active and are thirteen times more likely of being closed than being open. The crosstabulation presented in Table 5.9 indicates that for several conditions, the observed frequencies were much lower than the expected values.

Among female specimens with one side displaying no fusion and the other side displaying either active or closed condition, the observed values are much less than the expected values. This is most true of specimens that are open on one side and closed on the other side. For all specimens which are active on one side and closed on the other side, the observed values do not differ significantly from the expected values. The observed values are however higher than the expected values. For female specimens that are active on one side and open on the other side, the observed values are much less than the expected values. For all specimens that exhibit bilateral symmetry, the observed values are much greater than the expected values. The most likely predictor of fusion status on one side of an element, is the condition that exists on the other side.

To test the association between fusion status and age, a second chi square contingency table was generated (see Table 5.10). This table provides the observed and the expected values for the three stages of fusion for the left side for males and females by age groups. The number of observed incidences of non-fusion (open) exceeds the expected number for males and females, in the first four decades of life. This trend is reversed in specimens over age fifty

Table 5.10 Crosstabulation of fusion condition on left side by age group for males and females.

Age	Male				Female			
	Left Horn Fusion							
	Open	Active	Closed	N	Open	Active	Closed	N
0-9	26* 14.9**	0 6.2	0 4.9	26	9 5.6	0 2.2	0 1.2	9
10-19	77 44.7	1 18.7	0 14.6	78	34 21.2	0 8.1	0 4.7	34
20-29	175 120.4	21 50.2	14 39.4	210	52 40.5	11 15.5	2 9	65
30-39	151 137	55 57.2	33 44.8	239	63 59.2	21 22.7	11 13.1	95
40-49	126 153.1	78 63.9	63 50	267	58 60.4	25 23.2	14 13.4	97
50-59	101 126.7	67 52.9	53 41.4	221	34 34.3	14 13.2	10 7.6	55
60-69	66 91.2	53 38	40 29.8	159	20 29.3	17 11.2	10 6.5	47
70+	52 86	48 35.9	50 28.1	150	22 38.6	23 14.8	17 8.6	62
Totals	774	323	253	1350	289	111	64	464

* Observed
** Expected

where the number of specimens coded as open on the left side is less than the expected number. The disparity is greater for males than for females. Specimens coded as closed were observed with much less frequency than expected in the youngest three age groups. Whereas specimens from the 50-59, 60-69 and 70+ age groups were observed as fused more frequently than expected. For all fusion conditions there is little discrepancy between the observed and expected frequencies for both males and females from the 40-49 and 50-59 year age groups. The Pearson chi-square values for females (65.956 df=14) and males (211.100 df=14) are significant indicating that a dependency exists between observed row and column values.

Similar trends characterize the degree of fusion between the right greater horn and hyoid body (see Table 5.11). Pearson chi-square for females is 53.978 df=14. Pearson chi-square for males is 222.671 df=14. The chi-square test is significant indicating that for the sample population, age and fusion are related.

Review of the tests of partial associations indicates that the interaction of LHF and RHF is significant (partial chi square of 902.967, $p<.001$), as are the interactions of age group and LHF and RHF (partial chi square of 82.212, $p<.001$; partial chi square of 86.354, $p<.001$).

Table 5.11 Crosstabulation of fusion condition on right side by age group for males and females.

Age	*Male*				*Female*			
	Right Horn Fusion							
	Open	*Active*	*Closed*	*N*	*Open*	*Active*	*Closed*	*N*
0-9	26* 15.3**	0 6.1	0 4.6	26	9 5.7	0 2.1	0 1.2	9
10-19	78 45.8	1 18.4	0 13.8	78	34 21.7	0 7.8	0 4.5	34
20-29	177 123.4	23 49.5	10 37.2	210	53 41.5	7 10.5	5 8.5	65
30-39	153 140.4	58 56.3	28 42.3	239	59 60.6	26 21.9	10* 12.5**	95
40-49	138 156.8	75 62.9	54 47.3	267	60 61.9	23 22.4	14 12.8	97
50-59	111 129.8	61 52.1	49 39.1	221	34 34.3	14 13.2	10 7.6	55
60-69	59 93.4	52 37.5	48 28.1	159	20 29.3	17 11.2	10 6.5	47
70+	51 88.1	49 35.3	50 26.6	150	22 38.6	23 14.8	17 8.6	62
Totals	793	318	239	1350	296	107	61	464

* Observed
** Expected

The counts of the degree of fusion for the left quadrant 1 (L1) and the left quadrant 2 (L2) are listed in Table 5.12. Expected count values are generated on the assumption that the degree of fusion in quadrant 1 is independent of the degree of fusion in quadrant 2. A review of Table 5.12 demonstrates several features. The condition in quadrant 1 is frequently the same as the condition in quadrant 2. In cases where the second quadrant was open the first quadrant was coded as open, with no instances where the first quadrant was coded as trace (2) or complete (3). In approximately half of the cases, (48%) both quadrants were coded as complete, i.e. no active fusion was apparent in these quadrants. Nearly one third (28%) of the specimens, a code of trace in the first quadrant was associated with a code of complete in the second quadrant.

Observed values were greater than expected for each case where the fusion condition in quadrant 1 was similarly coded in quadrant 2. In addition, greater than expected observations were made on specimens which were open (1) in quadrant 1 and trace (2) in quadrant 2. Fewer than expected values were noted when quadrant 1 was coded as complete and quadrant 2 was coded as trace and similarly, when L2 was coded as complete and L1 was coded as open. The Pearson Chi square value is 142.780, which is significant at the p=.010 level.

Table 5.12 Crosstabulation of Quadrant fusion for L1 and L2. Age, sex and ancestry pooled.

		Left Quadrant 2			***Totals***
		open	***trace***	***complete***	
Left Quadrant 1	***open***	11* 1.4**	21 9.2	24 45.4	56
	trace	0 4.2	44 26.8	120 133	164
	complete	0 5.4	6 35	208 173.6	214
Totals		11	71	352	434

* Observed
** Expected

Table 5.13 demonstrates the comparisons between quadrants 2 and 3 on the left side. Seventy-two percent of specimens were coded as complete in L2 and also complete in L3. Less than 5% of specimens were coded as open in both L2 and L3. In situations where L2 was open,(n=11) there were no instances where L3 was complete. Observed values were much greater than expected in situations where both quadrants received the same code. Similarly, observed values were greater than expected when one quadrant was coded as

Table 5.13 Crosstabulation of Quadrant fusion for L2 and L3. Age, sex and ancestry pooled.

		Left Quadrant 3			*Totals*
		open	*trace*	*complete*	
Left Quadrant 2	*open*	7* .5**	4 1.8	0 8.7	11
	trace	11 3.4	28 11.5	32 56.1	71
	complete	3 17	38 56.7	310 277.2	351
Totals		21	70	342	433

* Observed
** Expected

trace and the adjacent quadrant was coded as open. Observed values were much less than expected for situations where one quadrant was open and the adjacent quadrant was closed. The Pearson chi squared value (162.166, df=4 p=.010) is significant suggesting that a relationship does exist for the degree of active fusion between L2 and L3.

A comparison of observed versus expected values for the degree of fusion for the third and fourth quadrants on the left side is presented in Table 5.14. Of note is that 79% of all specimens exhibit complete fusion for L3.

Table 5.14 Crosstabulation of Quadrant fusion between L3 and L4. Age, sex and ancestry pooled.

		Left Quadrant 4			***Totals***
		open	***trace***	***complete***	
Left Quadrant 3	***open***	19* 8.4**	1 10.8	1 1.8	21
	trace	37 28.1	26 35.9	7 6	70
	complete	118 137.4	195 175.3	29 29.2	342
Totals		174	222	37	433

* Observed
** Expected

Forty-five percent of specimens exhibit complete fusion in the third quadrant and exhibit trace fusion in the fourth quadrant. Less than 2% of specimens exhibit complete fusion in the fourth quadrant and exhibit trace fusion in the third quadrant. Twenty seven percent of all specimens exhibit complete fusion in L3, and are open in L4, whereas only one specimen is open in L3 and completely fused in L4. Less than five percent of the specimens were coded as open in L3 while 40% were coded as open in L4. Pearson chi square value with 4 degrees of freedom is 33.077.

The observed and expected values for fusion of L4 and L1 are presented in Table 5.15. Within the fourth quadrant, 51% were coded as trace in L4, many of these were coded as complete in L1. Thirty-one percent of all specimens exhibited complete fusion in L1 and trace fusion in L4. Less than 10% of specimens were coed as complete in L4. Pearson chi square value is 81.715, df=4 p=.01, indicating that the condition of active fusion degree of closure in one quadrant is related to the degree of closure in an adjacent quadrant.

Crosstabulations of R1 and R2 demonstrate that 43% of specimens are complete for both quadrants (see Table 5.16). Twenty-eight percent are complete in R2 and trace in R1. Less than 5% of all specimens were coded as open in R2, with a single incidence each of R1 coded as trace and complete. In the first quadrant, 21% of all specimens were coded as open and 34% as trace. A comparison of observed versus expected values indicates that much greater than expected counts were noted when R2 was coded as trace and R1 as open and as trace. The Pearson chi square value for R1 and R2 indicates that the conditions of active fusion between these quadrants are not independent (117.776, p=.010).

Table 5.15 Crosstabulation of Quadrant fusion for L4 and L1. Age, sex and ancestry pooled.

		Left Quadrant 1			*Totals*
		open	*Trace*	*complete*	
Left Quadrant 4	*open*	49* 22.5**	51 65.8	74 85.8	174
	trace	3 28.8	87 84.3	133 110	223
	complete	4 4.8	26 14	7 18.2	37
Totals		56	164	214	434

* Observed
** Expected

Table 5.17 presents the observed and expected counts for conditions of active fusion for the second and third quadrants on the right side. Observed counts exceeded expected counts when both quadrants exhibited the same degree of active fusion. For all specimens, 66% were coded as complete in both R2 and R3. Observed counts were greater than expected when R3 was coded as

Table 5.16 Crosstabulation of Quadrant fusion for R1 and R2. Age, sex and ancestry pooled.

		Right Quadrant 2			***Totals***
		open	***Trace***	***complete***	
Right Quadrant 1	***open***	18* 4.2**	32 17.6	39 67.2	89
	trace	1 6.8	42 28.5	101 108.8	144
	complete	1 9	10 37.9	181 145	192
Totals		20	84	321	425

* Observed
** Expected

open and R2 was coded as open or trace. Observed counts were much less than expected when one quadrant was coded as open and the other was coded as complete. For the following three conditions, approximately 8% of specimens were coded as trace at both R2 and R3, 8% as trace at R2 and complete in R3, and 8% as trace in R3 and complete in R2. Pearson chi square (108.441 df=4 p=.010) indicates that the degree of fusion in quadrants R2 and R3 are associated.

Table 5.17 Crosstabulation of Quadrant fusion for R2 and R3. Age, sex and ancestry pooled.

		Right Quadrant 3			***Totals***
		open	***trace***	***complete***	
Right Quadrant 2	***open***	14* 1.8**	5 3.3	1 14.8	20
	trace	15 7.7	36 14	33 62.3	84
	complete	10 29.5	30 53.6	281 237.9	321
Totals		39	71	315	425

* Observed
** Expected

The observed and expected counts of active fusion conditions for R3 and R4 are provided in Table 5.18. Approximately 40% of all specimens are complete in R3 and trace in R4. For all specimens, approximately 30% are complete in R3 and open in R4. A single case of trace fusion and two cases of complete fusion in R4 were recorded when R3 was coded as open. For R3, 75% of specimens were complete, with 9% open and 17% active. In R4, the opposite

Table 5.18 Crosstabulation of Quadrant fusion for R3 and R4. Age, sex and ancestry pooled.

		Right Quadrant 4			***Totals***
		open	***trace***	***complete***	
Right Quadrant 3	***open***	36* 18**	1 17.3	2 3.8	39
	trace	40 32.7	20 31.4	11 6.8	71
	complete	120 145.3	167 139.3	28 30.4	315
Totals		196	188	41	425

* Observed
** Expected

pattern was noted. R4 was observed as open in 46% of specimens, trace in 44%, and complete in approximately 10%. Pearson chi square52.518, df=4 p=.010, indicates the dependence of cell fusion between R3 and R4.

A crosstabulation of observed and expected values for degree of fusion in R4 and R1 is provided in Table 5.19. Pearson chi square is 122.782, df=4, p=.010 demonstrating that degree of fusion in R4 is dependent upon the degree of fusion in R1. In contrast to the other crosstabulations for the right side, the highest cell percentage did not occur when both R4 and R1 were complete. The

Table 5.19 Crosstabulation of Quadrant fusion for R4 and R1. Age, sex and ancestry pooled.

		Right Quadrant 1			***Totals***
		open	***trace***	***complete***	
Right Quadrant 4	***open***	83* 41**	49 66.4	64 88.5	196
	trace	3 39.4	67 63.7	118 84.9	188
	complete	3 8.6	28 13.9	10 18.5	41
Totals		89	144	192	425

* Observed
** Expected

highest percentage of cell counts (28%) occurred when R4 was coded as closed and R1 was coded as trace. However, the coding of R1 as closed and R4 as trace occurred in less than 7% of specimens. Less than 3% percent of specimens were complete in both R4 and R1; cell values much less than expected. Values were much lower than expected for R4 as trace and complete in cases where R1 was coded as open. Cell counts were also lower than expected, though not as much as noted above, for R1 as trace and complete when R4 was coded as open.

Observed cases exceeded expected cases when both quadrants were coded as open.

This series of chi square tests of independence for adjacent quadrants indicates that the degree of active fusion in a quadrant is associated with the degree of active fusion in a bordering quadrant. This trend is apparent for all adjacent quadrants on both the left and right sides. In addition, the cell counts of observed values and expected values are similar for adjacent quadrants when the left and right sides are compared. The highest frequencies recorded were for complete fusion in quadrants L2, L3 and R2 and R3. High values were alsonoted for trace fusion in L4 and R4 and also in L1 and R1. However in the first quadrants the counts for complete fusion were slightly higher than the counts for trace fusion. In the fourth quadrants the counts for complete fusion were much lower than the counts for trace fusion.

Chapter VI

Discussion

Introduction

This study has yielded information regarding growth and development of the human hyoid bone. Results demonstrate associations between the demographic attributes of age, sex and the metric aspects of hyoid bone size and shape. In addition, results suggest particular parameters influence the condition and pattern of union between the greater horns and the body of the hyoid bone. Hyoid body size measurements indicate that the hyoid bone does exhibit sexual dimorphism. Similarly, dimensions of the posterior greater horns are sexually dimorphic. Furthermore, fusion data suggest that age can no longer be considered a primary indicator of fusion condition. The implications of these findings will have applications upon clinical, developmental, and pathological, treatment and procedures.

Morphological Variation

Measurement data demonstrates that a high degree of morphological variation characterizes the hyoid bone. This variability is primarily apparent among specimens over twenty years of age. The range of variation is illustrated in Figure 6.1, which depicts five specimens all of whom are white males 46 and 47 years of age. Little morphological variation is visible among specimens from the youngest two age groups (0-9 and 10-19). This may in part be a product of the smaller sample sizes for specimens 0 to 19 years of age. With respect to the dimensions of the hyoid investigated in this study, height exhibits greater variation than other measures of the hyoid body. The mean height measure (pooled by sex) is approximately 10.5 mm with values exceeding 17mm and less than 7mm (see Figure 5.3). The mean width dimension among specimens is approximately 20 mm. with values recorded of greater than 27 mm and less than 12 mm (see Figure 5.5). Variability in body thickness is apparent for all specimens, regardless of age (see Figure 5.6). The mean is approximately 2 mm with values in excess of 4 mm and less than 1 mm.

A high degree of variation characterizes the dimensions of the posterior aspects of the greater horns; greater horn span (see Figure 5.7), greater horn distance (see Figure 5.8), and mean tip thickness (see Figure 5.9). It is noted that these measures are highly redundant. The range of morphological variation in the posterior distance between the greater horns, GHS, is great with an approximate mean of 46 mm and values ranging between 16 mm and 71 mm. Specimens demonstrate a continuous range of values for GHS. This prohibits classification into discrete categories based on shape as suggested by Papadoupolous et al. (1989). The results of this study demonstrate that the hyoid bone is characterized

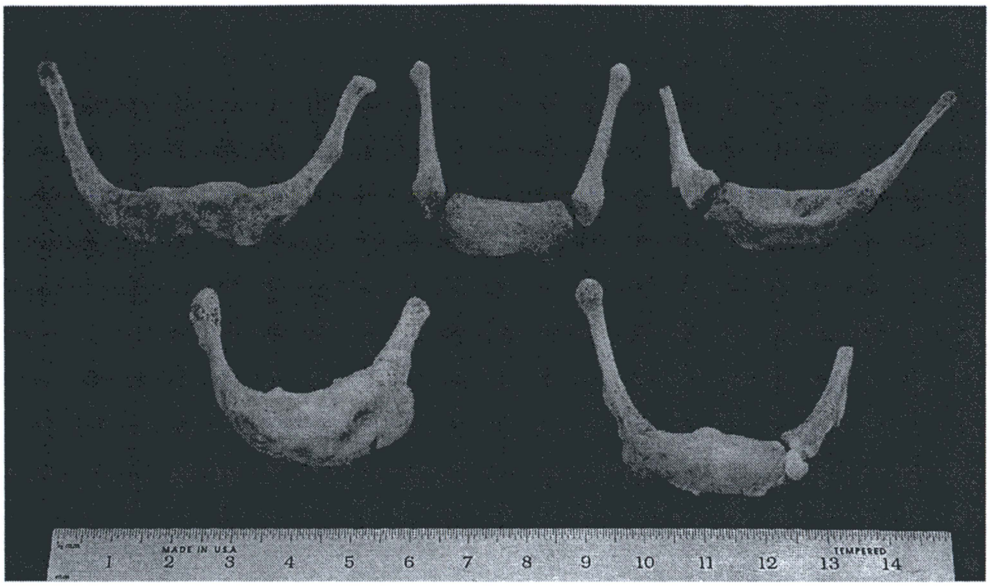

Figure 6.1 Morphological variation as seen on four hyoids of same sex, age and ancestry; white males 46 and 47 years of age.

by significant morphological variation. However these data do not allow for a discussion regarding symmetry, or asymmetry, of the hyoid bone.

Size and Shape

Analysis of the measurements of the hyoid body demonstrates there are significant differences in mean size between males and females. Males exhibit taller, wider, and thicker hyoid bodies in comparison to females. This supports the findings of the majority of published examinations even though those conclusions are based upon studies incorporating limited sample sizes. The absence of standardized anatomical landmarks for measuring the hyoid bone prohibits a direct comparison of measurements between researchers. However, this does not negate the potential for a comparative assessment of conclusions drawn from size data.

Jelisiejew et al., (1968) state that the hyoid bone demonstrates distinct sexual dimorphism. This comment is supported by Parsons (1909), who notes that sex can be differentiated by measures of the hyoid bone, particularly measurements of the hyoid body. Similarly, Komenda and Cerny (1990) claim that sexual dimorphism characterizes the hyoid bone. The mean values collected by Parsons are based upon a collection of 81 adult specimens. Jelisiejew and coworkers (1968) measured radiographs of 211 adult specimens (aged 21-82). All studies primarily focused on subjects over 20 years of age. According to their examinations, on average, males exhibit slightly larger measures in comparison to females (Parsons, 1909; Jelisiejew et al., 1968; Komenda and Cerny, 1990 and Miller et al., 1998).

This study demonstrates that there are significant differences in mean dimensions of the hyoid body between males and females. This is also true for mean dimensions of the posterior greater horns, span and distance and tip thickness, with males larger than females. There are several facets of these dimensions that warrant consideration. Both height and width dimensions of the hyoid body increase during the first two decades of life. Such is in following with distance curves of growth for body systems which promote fairly constant increases in size for individuals from birth to 18 years of age (see Bogin, 2000).

In this study, continuity in body shape is maintained during the middle year age groups. The apparent decrease in these dimensions found for specimens over 90 years of age may be a factor of sample size.

The relationship between height and width measures, which when considered together, reflect shape of the hyoid body provides interesting information. Table 6.1 provides a value of squareness for the body derived from mean height and width values. A value of 1 would indicate a square shape. Specimens from the youngest age group demonstrate the most square shape of all age groups (0.719). Further, it was noted that many of these square shaped hyoid bodies appear flat in the anteroposterior dimension. The posterior concavity often associated with the body is not apparent among young individuals. During the second and third decades a gradual decrease in the square shape is noted. During the middle year age groups (40-49, 50-59, 60-69, and 70-79) the hyoid body exhibits a more rectangular shape, with this trend reversing for specimens from the 80-89 year age group (see Figure 6.2).

Table 6.1 Body Shape derived from mean BH and BW values by age group. Sex and ancestry are pooled. Value of 1 is a square.

Age Group	***0-9***	***10-19***	***20-29***	***30-39***	***40-49***	***50-59***	***60-69***	***70-79***	***80-89***	***90+***
Body Shape	.719	.607	.534	.516	.514	.505	.515	.508	.526	.483

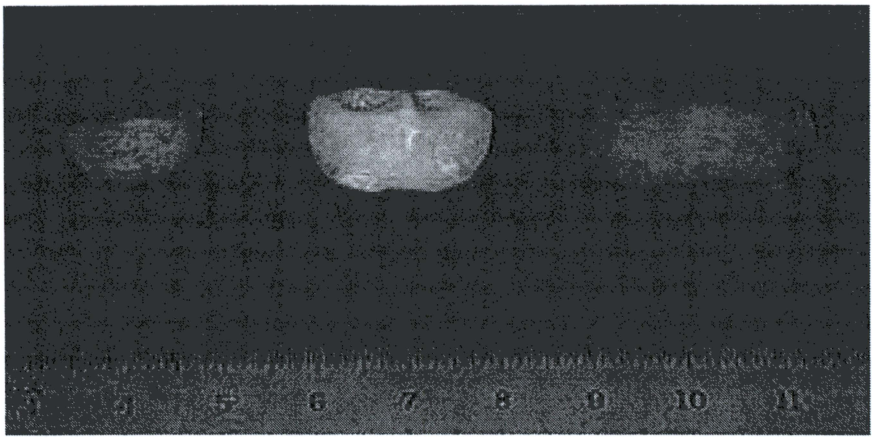

Figure 6.2 Specimens from three decades depicting body shape. Left to right, 0-9 age group, 10-19 age group, 30-39 age group.

The body thickness measurement provides developmental information. Most notably, the smallest values are not associated with the youngest individuals; the thickness of the body is fairly constant across the sample population. Both the largest and the smallest values were collected on individuals from the middle decades of life. This aspect of the hyoid bone does not mature in a manner that is consistent with published growth curves for other body systems. The basic developmental pattern of an increase in size occurring with an increase in age is not apparent for the thickness of the hyoid body (see Figure 6.3).

In this study, the posterior distance between the lateral aspects of the greater horns demonstrates differences attributable to sex. This measure was not

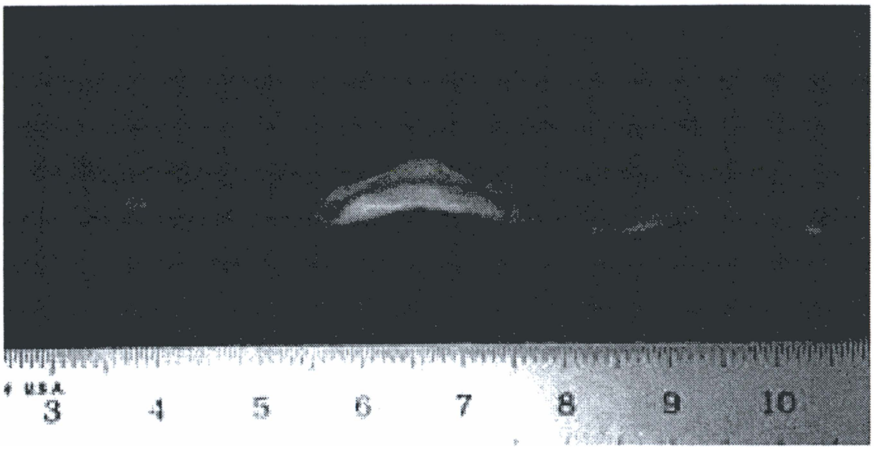

Figure 6.3 Specimens from different age groups depicting body thickness. Left to right, 0-9 age group, 10-19 age group, 30-39 age group.

recorded on specimens in which the body and the horns were separate. This dimension is analogous to the width of the bone as collected by Jelisiejew et al. (1968) who claim great differences exist between males and females for this measure. Jelisiejew and coworkers recorded the distance between the posterior most projection of the greater horns. As such, asymmetrical horn length would influence this measure. Miller et al. (1998) collected this measure, one of five incorporated into their discriminant function. Body width was utilized as well. However, this function correctly classifies females 69% and males 75% of the time. They note that length measures are much more sexually dimorphic than width measures.

The interior span and the mean thickness of the posterior horn projections as measured in the present study are also sexually dimorphic. It was noted that the posterior aspects of short unfused greater horns often exhibited a truncated appearance (see Figure 6.4). Reconsideration of the demographic components indicates that this trait is most often seen on horns of young subjects. This pattern was similarly noted by others (Jelisiejew et al., 1968 and Miller et al., 1998). Their research further supports another trend noted during the course of this study. Greater horns on specimens of advanced age demonstrate a

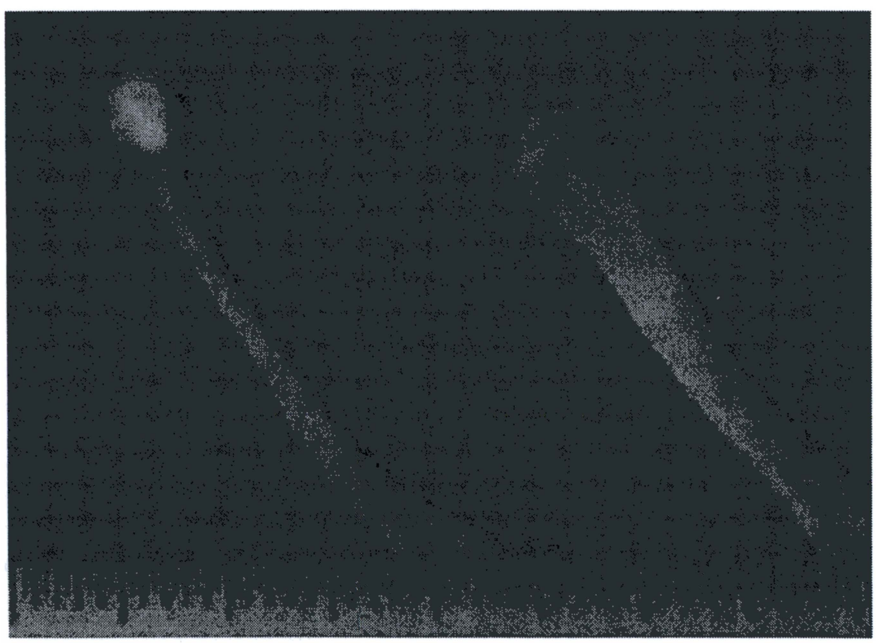

Figure 6.4 Comparison of posterior greater horns. Clubbed on left and truncated on right.

superoinferior flattening. This degenerative feature may be a product of muscular forces (see Figure 6.5).

This study indicates there are significant differences in mean hyoid body values between males and females. Although the mean values for males are greater than the mean values for females, the noted trends in height and width of the hyoid body characterize both male and female specimens. Increases in size demonstrate a linear relationship with increases in age which is apparent during the first two decades of life. During the middle years continuity in shape is maintained. Miller et al., though referring specifically to the posterior horn, suggest that age differences between male and female specimens may "have contributed to the sexual dimorphism we observed" (1998:1141).

Figure 6.5 Comparison of greater horns. Flattened on right tubular on left.

Fusion

These results demonstrate that increasing age does not dictate fusion between the body and the greater horns. This examination indicates that an intermediate stage, herein referred to as active fusion, is a recognizable stage of fusion between the body and the greater horns. As continuously promoted in the anatomical literature, that an increase in age incurs an increase in the frequency of fusion (see for example, Johnson and Moore, 1989; Hiatt and Gartner, 2001); this notion is not supported by the data from this study. The earliest incidence of complete fusion was noted in a white male, 21 years of age. Incidentally, this is the youngest individual with unilateral complete fusion. The oldest male with both sides open is a 92 year old white male, while a 101 black female also exhibits bilateral non-fusion.

An absence of complete union between the elements characterizes the first two decades of life, with upwards of 80% of specimens from the third decade of life also demonstrating no bony union (see Figures 5.10 and 5.11). It is often noted that fusion is common during the fourth decade of life. (see for example Jackson, 1914). However, the results of the present study indicate that among specimens from this decade, the 30 to 39 years age group, the absence of fusion occurs in over 60% of specimens. Although a gradual increase in the frequency of fusion characterizes specimens from the first five decades of life, (0 to 49 years), never more than 30% of specimens in an age group exhibit fusion between one or both greater horns and the body. As expected the increase in completely fused specimens coincides with a decrease in the numbers of specimens that exhibit an absence of fusion. However, the absence of fusion, for one or both sides, i.e. open, is noted for at least 35% of specimens in all age groups, with at least 50% exhibiting non fusion, of one or both sides, among specimens up to 60 years of age. Further, specimens over 60 years of age exhibit a moderately even distribution between the three stages of fusion, open, active, and closed, further contradicting the common assumption that advanced age is equated with fusion. These findings clearly contradict the accepted, and continuously perpetuated, view that fusion does, and will, occur among individuals of middle and advanced age.

O'Halloran and Lundy promote the view that there is a "trend toward greater frequency of bony union with increasing age" (1987:1657). They recorded complete fusion in 71.4% and 62.5% of male specimens aged 60-69 and 70+, respectively. However, among females, they found complete fusion in 22.2% and 57% of specimens aged 60-69 and 70+, respectively. Of interest is that they note, however, that "significant numbers of middle aged and elderly people have nonunion," (O'Halloran and Lundy, 1987:1657). Notably, O'Halloran and Lundy further state that data from an unpublished examination demonstrates that a stronger relationship exists between advanced age and fusion than they found. The correlation between age and fusion as considered by Miller et al (1998), is more comparable with the results of the present study. They note considerable variation in fusion condition for elderly individuals. Miller and coworkers recognized little difference between the sexes regarding fusion. These statements are substantiated by the results of the present study.

This study demonstrates there is a tendency towards symmetry in the fusion condition with never less than 70% of specimens in an age group demonstrating bilaterality of fusion conditions, i.e. both sides are open, active or fused. Statistical examinations demonstrated that the primary factor in dictating the fusion condition on one side of the bone is the condition that exists on the opposing side. Among all males, 13% demonstrate bilateral fusion and 49% demonstrate bilateral non-fusion. Among female specimens, bilateral fusion was noted in 8% of the study sample with 56% exhibiting bilateral non-fusion. Of interest is that complete fusion between both left and right greater horns and the hyoid body was noted in less than 20% of specimens in any age group. Males aged 70+ are the exception as this group exhibits bilateral fusion among 27% of specimens.

In the present study, overall, unilateral fusion was noted among 25% of males and 22% of females. There is not a tendency towards unilateral fusion conditions for either sex or in particular age groups. Among females, unilateral fusion conditions are apparent in less than 30% of specimens for any age group, occurring in only 9% of specimens from the third decade and noted in 24% of specimens from the fourth decade. Unilateral fusion is recognized in 14% of male specimens aged 20-29, in 26% of specimens aged 30-39, and approximately 30%

of male specimens in the older age groups. These results differ significantly from those of O'Halloran and Lundy,

> "By the third decade the percentages of cases with unilateral fusion was significant and remained so into old age. In age groups 3 through 8 (age 20 and older), 17% of the men and 40% of the women demonstrated unilateral nonfusion" (1987:1656).

Data from this study demonstrate that fusion conditions are not directly determined by the age of an individual. However, the present research does not provide information regarding the developmental aspects of fusion, i.e. why it occurs. Koebke, however, notes that

> "two divergent developmental tendencies can be taken into consideration. In some cases a joint is formed, other hyoid bones show characteristics indicating a possible fusion of the body and the greater horns" (1978:286).

Miller et al note that "fusion is not a continuous process" stating that individuals may have a genetic predisposition to remain open, or to fuse (1998:1139). These statements are supported by data from this study which demonstrate that an approximately equal occurrence of fusion, non-fusion and active fusion are seen among mature individuals.

Fusion patterns

The consideration of whether a pattern exists for fusion between the greater horns and the body of the hyoid has not been, to date, addressed. In fact, discussions of hyoid bones exhibiting partial fusion do not appear in anthropological or anatomical literature. Emphasis instead has been upon determining when fusion occurs, and not whether there is a recognizable pattern to the process. Results of the present study suggest that there are discernible patterns in the development of an osseous connection between the body and the greater horns.

A review of the crosstabulations of the degree of active fusion between adjacent quadrants demonstrates trends do in fact characterize this event. As demonstrated statistically, there are no differences between males and females, and the same trends characterize both sides of the bone. A comparison of the adjacent anterior quadrants, 1 and 2 indicate several trends. The majority of specimens, approximately 80%, exhibit complete fusion in quadrant 2. When this quadrant was coded as trace or open, quadrant 1 was coded as open or trace. Quadrant 1 was open or trace for approximately 30% of specimens. There were no instances when quadrant 1 was complete and quadrant 2 exhibited a condition other than complete.

The degree of fusion in quadrant 3 was found to be strongly correlated with the condition recorded in quadrant 2. There were very limited instances where either of these quadrants were open. A great majority of the specimens that exhibit complete fusion in quadrant 3 were coded as trace or open in quadrant 4, approximately 55% and 35% of the time, respectively. The open or trace degrees of active fusion were frequently noted in quadrant 4 with the adjacent quadrant 1 also demonstrating a high occurrence of trace active fusion. Several anomalous situations were noted where the fourth quadrant was complete and quadrant 1 was open. It is noted that this may be attributable to the presence of the lesser horns in this location.

Results of this study indicate that there is a tendency toward complete active fusion in the second and third quadrants coinciding with a high frequency of open or trace active fusion in the fourth quadrant and a high incidence of trace active fusion in the first quadrant. This commonly noted pattern suggests that fusion between the greater horns and the body occurs earliest at the inferior margin and progresses in a superior direction. Given that these data are cross sectional, and not longitudinal, it cannot be stated unequivocally that this describes the pattern of fusion between the greater horns and the body. However, given that there were no instances of complete fusion in the inferior quadrants with open fusion in the superior quadrants, it is likely that a progressive pattern does characterize fusion between these elements (see Figure 6.6).

The indication of a progressive pattern is comparable to results noted by Harrison and Denny (1983) who recognized patterns of ossification for cartilage elements of the adult human larynx. Occurring simultaneously in the thyroid and cricoid cartilages, ossification of the thyroid begins at the posteroinferior aspect and proceeds anteriorly and superiorly. Ossification of the cricoid cartilage begins across the posterosuperior border and proceeds anteriorly (Harrison, 1995). Noting it is rare prior to the third decade of life, Harrison (1995)

Figure 6.6 Depiction of common active fusion pattern. Open in 1 and 4 and complete in 2; progressing superiorly.

recognizes a direct correlation between advancing age and degree of ossification, with the stimulus attributed to both genetic factors and functional aspects of the larynx (Vastins and Vastins, 1952).

Forensic implications

Rao and Rao (1988) report on a case in which the death of a thirty-five year old individual was erroneously diagnosed as asphyxia with fracture of the hyoid bone. They noted that no external injuries were visible. Subsequent examination indicated that the mobility of the structures of the hyoid bone was due to non union of the body and the greater horn. The results of the present study demonstrate that fusion between the body and the greater horns is not common among individuals of this age. Of greater concern to the forensic pathologist is the high frequency of non-union between the body and the greater horns among individuals of advanced age. Undoubtedly, this must be considered when assessing a situation with possible laryngeal trauma. It can not be assumed that increasing age is reflective of a particular fusion condition. A more thorough examination of the skeletal components must be undertaken in cases of suspected laryngeal trauma.

Further, it should not be assumed that skeletal trauma will be evident on the hyoid bone as clinical research has indicated that the position of the hyoid bone varies in individuals, thereby suggesting that certain individuals may be more susceptible to fracture of the hyoid bone.

Conclusions

This study demonstrates several important aspects regarding the human hyoid bone. The bone does demonstrate sexual dimorphism. Tremendous variability is recognizable in the size and shape of the element. In addition, substantial disparity is apparent in fusion conditions for individuals. The data indicate that although there is an increase in the frequency of fusion between the body and greater horns with increasing age, this does not exist to the degree that has been promoted throughout the literature. In the present study, bilateral fusion was noted earlier (21 years) and bilateral non fusion was noted later (101 years) than in any other published reports. These data indicate that fusion can no longer be equated with advanced age, and likely that many individuals will never exhibit fusion. Further, such variation must be recognized and incorporated into pathological and clinical examinations.

Chapter VII

Conclusions

With respect to the goals of this project, the results can be summarized as follows:

1. Does overall size and shape, as depicted through a suite of measurements, correlate with age, sex and/or ancestry?

   - These results indicate that ancestry is not correlated with size and shape dimensions of the hyoid bone. However, small sample sizes for certain ancestral groups does not allow for a thorough examination of this parameter.
   - Measurement data indicates that sexual dimorphism characterizes the hyoid bone. Males on average are significantly larger than females across each measurement in this study.
   - Age influences overall size and shape of the hyoid bone, particularly height and width dimensions of the body. As expected dimensions are less among specimens from the first and second age groups. These decades are associated with growth and development of skeletal and organ systems. Continuity in size is maintained during the middle decades of life. This is not as true of the thickness of the hyoid body where there is little evidence for age dependent

increase in this dimension of the hyoid. This study demonstrates that age influences hyoid bone size and shape.

2. Are certain structural characters associated with sex or ancestry?

- Ancestry is not correlated with overall size and shape of the hyoid bone.
- Though sexually dimorphic, there is no evidence to suggest that sex influences fusion status of the hyoid bone.

3. Are there correlations between advancing age and the development of morphological features?

- Age is a factor in the determinant of morphological features of the hyoid bone. Young specimens demonstrate that the body is characteristically square in shape. Young specimens further exhibit an absence of concavity to the posterior body. Further, the thickness of the inferior aspect of the body is constant across all age groups. Examination further reflects a trend towards supero-inferior flattening of the greater horn with advanced age.

4. Can fusion between the components of the hyoid be correlated to age, sex and/or ancestry?

- Fusion between the body and the greater horns of the hyoid bone is not dependent upon the sex or ancestry of an individual. Age however, is a factor concerning union of the body and greater horns in that among the young (0-9 and 10-19) no union occurs. There is minimal evidence for the occurrence of fusion between the body and greater horns during the third and fourth decades of life. Although an increase in the frequency of union occurs during succeeding decades, advanced age cannot be equated with fusion between the body and greater horns. The frequency of specimens which exhibit complete fusion does not exceed approximately 30% of individuals within any age group beyond the sixth decade of life. In fact, the complete absence of any union between the body and the greater horns characterizes approximately 30% of individuals within the most mature age groups.

- The existence of a stage of fusion previously unmentioned in the scientific literature has been demonstrated. Herein referred to as active fusion, this stage is characterized by partial union between the body and the greater horns. An increase in the frequency of this condition is noted throughout the decades, though never accounting for more than 30% of individuals within any age group.

5. Is there a pattern to the fusion between the body and the greater horns of the hyoid bone?

- Fusion between the body and the greater horns follows a recognizable pattern.

- Union between these elements of the hyoid bone occurs initially at the inferior aspect and progresses superiorly.

6. What are the implications of this study, for pathologists, anthropologists and clinicians?

   - The implications of this study upon pathological, anthropological, and clinical examinations are great.
   - First, the hyoid bone demonstrates sexual dimorphism.
   - A high degree of variation characterizes the hyoid.
   - The notion that advanced age is directly correlated with fusion between the greater horns and the body can no longer be assumed. Examinations of the hyoid bone may now be conducted from a more informed perspective given the demonstrated variation in overall size and shape and fusion condition which characterizes the hyoid bone.

Finally, morphological considerations of the hyoid bone demonstrate that this skeletal element is characterized by a high degree of variation. This diversity is apparent in both overall dimensions of the bone and in the fusion between the body and the greater horns. The traditional description of the hyoid bone, most frequently as a "u shaped" single fused element, is inaccurate. Further, the notion of a causal relationship between advancing age and fusion of the body and the greater horns is also inaccurate. This increased awareness of the variability that truly characterizes this bone will enable greater pathological, anthropological, anatomical, and clinical examinations, with morphological accuracy, of the human hyoid bone.

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Appendices

Appendix A

Sample demographics by specimen sorted by age and sex

Specimen	*Sex*	*Age*	*Ancestry*
95.001	2	0.1	1
92.058	2	0.2	1
93.227	2	0.2	1
98.011	1	0.25	1
93.067	2	0.25	1
93.143	1	0.3	1
93.150	1	0.3	1
88.141	2	0.3	1
88.034	1	0.4	1
89.012	2	0.5	1
95.094	2	0.5	1
97.034	2	0.5	1
97.232	2	0.5	1
92.067	2	0.7	1
93.037	2	0.7	1
92.060	1	1	1
87.063	2	1.5	1
92.056	1	2	1
93.054	2	2	1
89.010	2	2.5	2
96.248	1	3	1
88.172	2	3	1
92.037	2	3	1
93.129	2	3	1
95.109	2	3.5	1
94.105	1	4	2
89.022	2	4	1
89.020	2	4.5	1
97.087	2	6	1
98.036	2	6	1
88.158	2	7	1
89.082	2	7	1
97.056	1	8	2

Specimen	*Sex*	*Age*	*Ancestry*
89.080	2	8	1
94.094	2	8	1
88.020	2	10	1
89.048	2	10	1
92.115	2	10	1
93.003	2	10	1
95.040	2	10	1
96.211	2	10	1
93.170	2	11	1
88.156	1	12	1
89.008	1	12	1
92.027	1	12	1
88.122	2	12	1
96.207	2	12	1
94.045	1	13	1
94.147	1	13	1
93.048	2	13	1
01.110a	2	13	1
92.029	1	14	1
88.009	2	14	1
88.053	2	14	1
88.099	2	14	1
94.064	2	14	1
92.100	1	15	1
92.150	1	15	1
98.095	1	15	1
87.061	2	15	1
88.079	2	15	2
88.155	2	15	1
92.028	2	15	1
92.063	2	15	1
92.141	2	15	1
92.151	2	15	1

Specimen	*Sex*	*Age*	*Ancestry*
93.195	2	15	1
96.092	2	15	5
96.201	2	15	1
96.221	2	15	1
93.118	1	16	1
94.047	1	16	1
94.077	1	16	1
95.082	1	16	1
95.157	1	16	1
96.115	1	16	1
98.012	1	16	1
87.087	2	16	1
88.151	2	16	1
88.154	2	16	1
89.011	2	16	1
93.051	2	16	1
94.135	2	16	1
95.155	2	16	1
96.156	2	16	1
98.050	2	16	1
87.162	1	17	1
92.112	1	17	1
93.175	1	17	1
93.221	1	17	1
95.085	1	17	1
95.217	1	17	1
87.148	2	17	1
87.153	2	17	1
89.065	2	17	1
93.174	2	17	1
94.079	2	17	1
94.095	2	17	1
94.195	2	17	1

Specimen	*Sex*	*Age*	*Ancestry*
96.067	2	17	1
97.096	2	17	1
97.155	2	17	1
97.227	2	17	1
93.068	1	18	1
93.138	1	18	1
93.226	1	18	1
94.141	1	18	1
94.185	1	18	2
95.115	1	18	1
89.024	2	18	1
89.091	2	18	1
92.079	2	18	1
93.049	2	18	1
93.078	2	18	1
94.076	2	18	1
95.080	2	18	1
96.058	2	18	1
96.059	2	18	1
96.116	2	18	1
96.133	2	18	1
96.180	2	18	1
96.250	2	18	1
97.125	2	18	1
97.177	2	18	1
98.058	2	18	1
87.073	1	19	1
94.011	1	19	1
94.162	1	19	1
94.184	1	19	2
94.194	1	19	1
96.136	1	19	1
87.050	2	19	1

Specimen	*Sex*	*Age*	*Ancestry*
88.008	2	19	1
92.078	2	19	1
93.230	2	19	1
94.072	2	19	1
94.093	2	19	1
94.101	2	19	1
94.110	2	19	1
95.066	2	19	2
95.068	2	19	1
96.030	2	19	1
96.216	2	19	1
97.209	2	19	1
98.025	2	19	1
98.046	2	19	1
98.048	2	19	1
87.018	1	20	1
87.075	1	20	1
93.171	1	20	1
93.205	1	20	1
95.038	1	20	1
96.215	1	20	1
98.068	1	20	1
87.023	2	20	1
87.049	2	20	1
87.117	2	20	1
87.161	2	20	1
88.087	2	20	1
89.069	2	20	1
92.035	2	20	1
92.048	2	20	1
93.147	2	20	1
94.006	2	20	1
95.026	2	20	1

Specimen	*Sex*	*Age*	*Ancestry*
95.045	2	20	1
95.091	2	20	1
95.104	2	20	1
96.159	2	20	1
96.171	2	20	1
96.208	2	20	1
97.044	2	20	4
97.046	2	20	1
97.205	2	20	4
93.072	1	21	1
95.147	1	21	1
95.149	1	21	1
87.084	2	21	1
89.006	2	21	1
89.019	2	21	1
92.119	2	21	1
93.041	2	21	1
93.127	2	21	1
93.128	2	21	1
94.035	2	21	1
95.032	2	21	1
95.039	2	21	1
96.038	2	21	1
96.066	2	21	1
96.147	2	21	1
97.088	2	21	1
98.056	2	21	1
87.112	1	22	1
95.090	1	22	1
87.059	2	22	1
87.122	2	22	1
87.149	2	22	1
88.025	2	22	1

Specimen	*Sex*	*Age*	*Ancestry*
88.074	2	22	1
88.090	2	22	1
88.102	2	22	1
88.166	2	22	1
92.068	2	22	1
92.136	2	22	1
93.140	2	22	1
93.159	2	22	1
93.222	2	22	1
94.062	2	22	1
94.151	2	22	1
94.170	2	22	1
95.151	2	22	1
96.135	2	22	1
96.257	2	22	1
98.038	2	22	1
87.092	1	23	1
89.099	1	23	1
92.066	1	23	1
92.135	1	23	1
94.182	1	23	1
94.202	1	23	1
97.076	1	23	1
87.164	2	23	1
88.017	2	23	1
92.179	2	23	1
93.017	2	23	1
93.066	2	23	1
94.029	2	23	1
94.086	2	23	1
94.122	2	23	1
95.126	2	23	1
95.150	2	23	1

Specimen	*Sex*	*Age*	*Ancestry*
95.162	2	23	1
95.203	2	23	4
95.210	2	23	1
96.070	2	23	1
96.134	2	23	1
96.160	2	23	5
97.007	2	23	1
97.117	2	23	1
97.194	2	23	1
95.057	1	24	1
96.247	1	24	1
87.021	2	24	1
87.027	2	24	1
87.058	2	24	1
87.146	2	24	1
88.080	2	24	1
88.131	2	24	1
89.044	2	24	1
92.071	2	24	1
92.130	2	24	1
93.075	2	24	1
93.080	2	24	1
94.069	2	24	1
95.154	2	24	4
95.171	2	24	1
96.015	2	24	1
96.132	2	24	1
97.011	2	24	1
97.030	2	24	1
97.037	2	24	1
98.064	2	24	1
89.083	1	25	2
93.219	1	25	1

Specimen	*Sex*	*Age*	*Ancestry*
94.208	1	25	1
95.213	1	25	1
96.096	1	25	1
97.221	1	25	1
88.029	2	25	1
88.106	2	25	1
88.110	2	25	1
89.059	2	25	1
89.071	2	25	1
89.088	2	25	2
92.073	2	25	2
93.040	2	25	1
93.142	2	25	1
93.168	2	25	1
94.023	2	25	1
94.059	2	25	1
95.106	2	25	1
95.189	2	25	1
96.083	2	25	1
96.101	2	25	1
97.168	2	25	1
97.213	2	25	1
98.008	2	25	1
98.061	2	25	1
87.157	1	26	1
88.036	1	26	1
88.057	1	26	1
88.073	1	26	1
88.108	1	26	1
93.043	1	26	1
94.168	1	26	1
95.071	1	26	1
96.011	1	26	1

Specimen	*Sex*	*Age*	*Ancestry*
01.105a	1	26	2
87.120	2	26	1
88.067	2	26	1
89.009	2	26	1
89.033	2	26	1
89.079	2	26	1
89.100	2	26	1
92.064	2	26	1
92.109	2	26	1
92.161	2	26	1
93.053	2	26	1
94.033	2	26	1
94.044	2	26	1
94.078	2	26	1
94.116	2	26	1
94.189	2	26	1
94.200	2	26	1
95.152	2	26	1
95.163	2	26	1
96.142	2	26	1
96.192	2	26	1
96.246	2	26	1
96.261	2	26	1
97.023	2	26	2
97.120	2	26	1
97.192	2	26	1
98.059	2	26	1
87.123	1	27	1
88.174	1	27	1
92.025	1	27	1
92.128	1	27	1
94.042	1	27	1
94.130	1	27	1

Specimen	*Sex*	*Age*	*Ancestry*
95.011	1	27	1
95.052	1	27	1
98.083	1	27	1
87.053	2	27	1
87.088	2	27	1
87.099	2	27	1
87.139	2	27	1
88.015	2	27	1
88.086	2	27	1
88.105	2	27	1
89.073	2	27	1
89.096	2	27	1
92.125	2	27	1
92.142	2	27	2
93.036	2	27	1
93.087	2	27	1
93.100	2	27	2
93.113	2	27	1
93.131	2	27	1
93.146	2	27	1
94.038	2	27	1
94.169	2	27	1
95.041	2	27	1
95.076	2	27	1
95.223	2	27	1
96.075	2	27	1
96.162	2	27	5
96.249	2	27	1
97.057	2	27	1
97.115	2	27	1
98.091	2	27	1
87.054	1	28	1
88.114	1	28	1

Specimen	*Sex*	*Age*	*Ancestry*
92.038	1	28	1
95.022	1	28	1
95.131	1	28	1
95.183	1	28	1
96.191	1	28	1
97.051	1	28	1
87.004	2	28	1
87.065	2	28	1
87.134	2	28	1
88.026	2	28	1
88.062	2	28	1
89.087	2	28	2
92.053	2	28	2
92.103	2	28	1
92.131	2	28	1
92.137	2	28	1
92.152	2	28	1
92.155	2	28	1
93.006	2	28	1
93.110	2	28	1
93.126	2	28	1
93.207	2	28	1
94.067	2	28	1
94.104	2	28	1
95.231	2	28	1
96.100	2	28	1
97.134	2	28	1
98.076	2	28	1
99.35f	2	28	1
87.107	1	29	2
89.007	1	29	1
92.061	1	29	1
92.090	1	29	1

Specimen	*Sex*	*Age*	*Ancestry*
95.005	1	29	1
95.015	1	29	1
95.137	1	29	1
95.177	1	29	1
97.105	1	29	1
97.222	1	29	1
96.5f	1	29	1
87.026	2	29	1
87.042	2	29	1
87.138	2	29	1
88.161	2	29	1
92.065	2	29	1
92.095	2	29	1
92.096	2	29	1
92.162	2	29	1
93.123	2	29	1
93.215	2	29	1
93.224	2	29	1
94.058	2	29	1
95.158	2	29	1
95.179	2	29	1
96.020	2	29	1
97.082	2	29	1
97.132	2	29	4
97.139	2	29	1
98.049	2	29	1
87.052	1	30	2
92.164	1	30	1
92.181	1	30	1
96.048	1	30	1
96.099	1	30	1
96.152	1	30	1
87.038	2	30	1

Specimen	Sex	Age	Ancestry
87.079	2	30	1
88.020	2	30	2
88.111	2	30	1
88.118	2	30	1
92.052	2	30	1
92.093	2	30	2
93.038	2	30	1
93.144	2	30	2
94.019	2	30	1
94.121	2	30	1
95.004	2	30	1
95.017	2	30	1
95.019	2	30	1
95.043	2	30	1
95.095	2	30	1
95.108	2	30	1
95.133	2	30	1
96.024	2	30	1
96.031	2	30	1
96.154	2	30	1
96.260	2	30	1
97.131	2	30	1
88.123	1	31	1
92.057	1	31	1
94.136	1	31	1
94.191	1	31	1
95.098	1	31	1
97.167	1	31	1
87.022	2	31	1
87.125	2	31	1
87.141	2	31	1
87.163	2	31	1
88.010	2	31	1

Specimen	*Sex*	*Age*	*Ancestry*
88.071	2	31	1
88.142	2	31	1
89.023	2	31	1
89.070	2	31	1
92.059	2	31	1
92.172	2	31	1
93.046	2	31	1
93.151	2	31	1
94.160	2	31	1
94.207	2	31	1
95.100	2	31	1
95.112	2	31	1
95.143	2	31	1
96.028	2	31	1
96.175	2	31	1
96.212	2	31	2
96.254	2	31	1
97.036	2	31	1
97.145	2	31	1
98.027	2	31	1
98.060	2	31	1
98.066	2	31	1
87.080	1	32	1
87.152	1	32	1
89.038	1	32	1
89.043	1	32	1
89.085	1	32	1
93.167	1	32	1
93.220	1	32	1
94.166	1	32	1
96.234	1	32	1
87.006	2	32	1
87.144	2	32	1

Specimen	*Sex*	*Age*	*Ancestry*
88.005	2	32	1
88.097	2	32	1
88.167	2	32	1
92.018	2	32	1
92.091	2	32	1
92.124	2	32	1
93.004	2	32	1
93.071	2	32	1
93.111	2	32	1
93.148	2	32	1
94.040	2	32	1
94.081	2	32	1
94.145	2	32	1
94.161	2	32	1
94.172	2	32	1
95.081	2	32	1
95.084	2	32	1
96.041	2	32	1
96.051	2	32	1
96.064	2	32	1
96.145	2	32	1
96.239	2	32	1
97.010	2	32	1
97.060	2	32	1
98.006	2	32	1
98.065	2	32	1
14.93	2	32	1
87.068	1	33	1
92.084	1	33	1
93.065	1	33	1
93.211	1	33	1
95.087	1	33	1
95.102	1	33	1

Specimen	***Sex***	***Age***	***Ancestry***
96.138	1	33	1
96.238	1	33	1
96.245	1	33	1
97.150	1	33	1
87.062	2	33	1
87.145	2	33	1
88.007	2	33	1
89.039	2	33	1
89.053	2	33	1
89.055	2	33	1
93.028	2	33	2
93.121	2	33	1
94.061	2	33	1
94.117	2	33	1
94.183	2	33	1
95.070	2	33	1
96.027	2	33	1
96.050	2	33	1
96.213	2	33	1
97.013	2	33	1
98.082	2	33	1
87.115	1	34	1
92.022	1	34	2
94.108	1	34	1
95.144	1	34	1
95.156	1	34	1
96.018	1	34	1
96.233	1	34	1
98.041	1	34	1
87.116	2	34	1
87.156	2	34	1
88.041	2	34	1
88.149	2	34	1

Specimen	*Sex*	*Age*	*Ancestry*
88.162	2	34	1
89.005	2	34	1
89.066	2	34	1
92.099	2	34	1
92.121	2	34	1
92.132	2	34	2
92.176	2	34	1
93.018	2	34	1
93.045	2	34	1
93.157	2	34	1
94.010	2	34	1
95.121	2	34	1
97.052	2	34	1
97.229	2	34	1
98.039	2	34	1
95.12f	2	34	1
98.3f	2	34	2
92.101	1	35	1
93.002	1	35	1
93.019	1	35	1
94.089	1	35	1
94.097	1	35	1
95.136	1	35	1
97.004	1	35	1
97.009	1	35	1
97.111	1	35	1
98.026	1	35	1
87.034	2	35	1
87.081	2	35	1
88.013	2	35	1
88.054	2	35	1
88.112	2	35	1
88.144	2	35	1

Specimen	***Sex***	***Age***	***Ancestry***
89.040	2	35	1
93.163	2	35	1
93.193	2	35	1
93.199	2	35	1
93.209	2	35	1
94.126	2	35	1
95.029	2	35	1
95.063	2	35	1
96.109	2	35	1
96.264	2	35	1
97.095	2	35	1
97.160	2	35	1
98.015	2	35	1
98.052	2	35	1
98.053	2	35	1
89.037	1	36	2
91.040	1	36	1
92.026	1	36	1
92.133	1	36	1
93.088	1	36	1
93.139	1	36	1
93.183	1	36	2
93.187	1	36	1
95.050	1	36	1
95.077	1	36	1
95.138	1	36	1
96.080	1	36	1
96.086	1	36	1
96.163	1	36	2
96.174	1	36	1
87.017	2	36	1
87.090	2	36	1
87.150	2	36	1

Specimen	*Sex*	*Age*	*Ancestry*
92.045	2	36	1
92.046	2	36	1
92.069	2	36	1
92.116	2	36	1
93.026	2	36	1
93.095	2	36	1
93.194	2	36	1
93.228	2	36	1
94.022	2	36	1
94.050	2	36	1
95.035	2	36	1
95.053	2	36	1
95.140	2	36	1
96.002	2	36	1
96.007	2	36	1
96.146	2	36	1
96.195	2	36	1
96.202	2	36	2
96.225	2	36	2
97.201	2	36	1
98.018	2	36	1
98.035	2	36	1
98.042	2	36	1
3.87	2	36	1
2.89	2	36	1
94.19f	2	36	1
87.067	1	37	1
88.044	1	37	1
88.095	1	37	1
92.081	1	37	1
92.105	1	37	1
93.050	1	37	1
94.008	1	37	1

Specimen	*Sex*	*Age*	*Ancestry*
94.013	1	37	1
95.042	1	37	1
95.051	1	37	1
96.179	1	37	2
97.164	1	37	1
87.114	2	37	1
87.128	2	37	2
88.136	2	37	1
92.143	2	37	1
92.160	2	37	1
92.166	2	37	1
93.039	2	37	1
93.073	2	37	1
94.002	2	37	1
94.052	2	37	1
94.070	2	37	1
94.180	2	37	1
95.073	2	37	1
95.201	2	37	1
95.208	2	37	1
95.232	2	37	1
96.025	2	37	1
96.062	2	37	1
96.072	2	37	1
96.108	2	37	2
96.204	2	37	1
96.218	2	37	1
96.258	2	37	1
97.053	2	37	1
97.107	2	37	1
97.138	2	37	1
98.047	2	37	1
98.071	2	37	1

Specimen	*Sex*	*Age*	*Ancestry*
95.3f	2	37	1
88.032	1	38	1
88.165	1	38	1
92.042	1	38	1
93.027	1	38	1
93.052	1	38	1
94.112	1	38	1
94.155	1	38	1
96.065	1	38	1
97.021	1	38	1
97.181	1	38	2
27.91	1	38	1
88.033	2	38	1
88.078	2	38	1
88.100	2	38	1
88.127	2	38	1
93.015	2	38	1
93.022	2	38	1
93.102	2	38	1
93.133	2	38	1
94.054	2	38	1
94.205	2	38	1
95.036	2	38	1
95.129	2	38	1
95.160	2	38	1
95.165	2	38	2
95.169	2	38	1
96.196	2	38	1
96.205	2	38	1
96.209	2	38	1
96.229	2	38	1
96.262	2	38	1
97.161	2	38	4

Specimen	Sex	Age	Ancestry
97.186	2	38	1
98.007	2	38	1
98.073	2	38	1
5.99	2	38	1
88.035	1	39	1
92.030	1	39	1
92.051	1	39	1
93.217	1	39	1
94.066	1	39	1
95.181	1	39	1
95.188	1	39	1
98.019	1	39	1
88.140	2	39	1
89.095	2	39	1
92.145	2	39	2
93.084	2	39	1
93.141	2	39	1
93.165	2	39	1
93.188	2	39	1
94.196	2	39	2
95.047	2	39	1
95.054	2	39	1
95.060	2	39	1
95.190	2	39	1
95.200	2	39	1
97.017	2	39	1
97.073	2	39	1
97.119	2	39	1
98.093	2	39	1
1.87	2	39	1
87.132	1	40	1
88.040	1	40	2
88.045	1	40	1

Specimen	*Sex*	*Age*	*Ancestry*
88.048	1	40	1
89.032	1	40	2
93.096	1	40	1
93.166	1	40	1
96.019	1	40	1
96.023	1	40	1
96.049	1	40	1
97.157	1	40	1
97.172	1	40	1
97.173	1	40	1
98.10f	1	40	1
87.136	2	40	2
88.024	2	40	1
88.137	2	40	1
91.102	2	40	1
93.145	2	40	1
93.208	2	40	1
94.026	2	40	1
94.096	2	40	1
94.102	2	40	1
96.169	2	40	1
96.230	2	40	1
96.263	2	40	2
97.005	2	40	1
97.059	2	40	1
97.067	2	40	1
97.098	2	40	1
97.114	2	40	1
97.144	2	40	1
97.179	2	40	4
97.224	2	40	1
98.013	2	40	1
98.078	2	40	1

Specimen	*Sex*	*Age*	*Ancestry*
98.089	2	40	1
87.119	1	41	1
88.061	1	41	1
88.076	1	41	1
92.085	1	41	1
92.111	1	41	1
97.025	1	41	1
98.020	1	41	1
98.055	1	41	1
87.077	2	41	1
87.147	2	41	1
88.116	2	41	1
89.050	2	41	1
92.117	2	41	1
93.024	2	41	1
93.034	2	41	1
93.106	2	41	1
93.119	2	41	1
93.190	2	41	1
94.005	2	41	1
94.068	2	41	1
94.132	2	41	1
94.209	2	41	1
95.008	2	41	1
95.067	2	41	1
95.072	2	41	1
95.099	2	41	1
95.207	2	41	1
96.039	2	41	1
96.161	2	41	1
96.173	2	41	1
97.012	2	41	1
97.019	2	41	1

Specimen	*Sex*	*Age*	*Ancestry*
97.084	2	41	1
97.092	2	41	1
97.152	2	41	1
97.216	2	41	1
97.228	2	41	1
87.103	1	42	1
88.065	1	42	1
89.058	1	42	1
92.153	1	42	1
93.063	1	42	1
93.134	1	42	1
94.046	1	42	1
95.118	1	42	1
97.033	1	42	2
97.123	1	42	1
88.052	2	42	1
88.103	2	42	1
88.138	2	42	1
89.093	2	42	2
92.110	2	42	1
93.164	2	42	1
93.178	2	42	1
94.131	2	42	1
94.148	2	42	1
94.154	2	42	1
94.203	2	42	1
95.028	2	42	1
95.105	2	42	1
95.224	2	42	1
96.057	2	42	4
96.126	2	42	1
96.166	2	42	1
96.172	2	42	1

Specimen	*Sex*	*Age*	*Ancestry*
96.185	2	42	1
97.075	2	42	1
97.109	2	42	1
97.148	2	42	1
97.165	2	42	1
98.016	2	42	1
98.021	2	42	1
98.037	2	42	1
00.41f	2	42	1
87.118	1	43	1
93.083	1	43	1
94.134	1	43	1
96.032	1	43	1
96.060	1	43	1
97.211	1	43	1
98.024	1	43	1
87.008	2	43	1
87.106	2	43	1
87.121	2	43	1
88.124	2	43	1
92.134	2	43	2
93.001	2	43	2
93.042	2	43	1
93.103	2	43	1
93.107	2	43	2
93.115	2	43	1
93.184	2	43	1
94.003	2	43	2
94.139	2	43	1
94.156	2	43	1
94.206	2	43	1
95.064	2	43	1
95.107	2	43	1

Specimen	*Sex*	*Age*	*Ancestry*
95.170	2	43	1
95.174	2	43	1
95.178	2	43	1
96.033	2	43	1
96.094	2	43	1
96.143	2	43	1
96.167	2	43	1
96.227	2	43	1
97.026	2	43	1
97.048	2	43	1
97.081	2	43	1
97.149	2	43	1
97.196	2	43	1
9.89	2	43	2
3.9	2	43	1
88.129	1	44	2
94.109	1	44	1
95.166	1	44	1
95.197	1	44	1
96.036	1	44	1
96.219	1	44	1
97.028	1	44	1
96.13f	1	44	1
87.111	2	44	1
88.171	2	44	1
89.014	2	44	1
92.023	2	44	1
92.032	2	44	2
92.033	2	44	1
92.107	2	44	1
93.025	2	44	1
93.120	2	44	1
93.179	2	44	1

Specimen	*Sex*	*Age*	*Ancestry*
93.218	2	44	1
94.048	2	44	1
94.051	2	44	1
94.075	2	44	1
94.106	2	44	2
94.12	2	44	1
94.171	2	44	1
95.023	2	44	1
96.045	2	44	1
96.047	2	44	1
96.068	2	44	1
96.122	2	44	1
96.157	2	44	1
96.232	2	44	1
96.235	2	44	1
96.237	2	44	1
97.008	2	44	1
97.031	2	44	1
97.102	2	44	1
97.189	2	44	1
97.191	2	44	1
97.233	2	44	1
87.004p	1	45	1
87.033	1	45	1
87.135	1	45	1
88.093	1	45	1
88.157	1	45	1
88.173	1	45	1
94.127	1	45	1
97.022	1	45	1
97.058	1	45	1
97.126	1	45	1
28.9	1	45	1

Specimen	*Sex*	*Age*	*Ancestry*
86.073	2	45	1
87.009	2	45	1
87.024	2	45	1
87.039	2	45	2
87.045a	2	45	1
87.091	2	45	1
87.095	2	45	1
87.155	2	45	1
88.168	2	45	1
88.170	2	45	1
92.080	2	45	1
92.180	2	45	1
93.005	2	45	1
93.108	2	45	1
94.118	2	45	1
95.065	2	45	1
95.134	2	45	1
97.003	2	45	1
97.038	2	45	1
97.085	2	45	1
97.141	2	45	1
97.147	2	45	2
97.153	2	45	1
97.217	2	45	1
98.063	2	45	1
98.075	2	45	1
1.94	2	45	1
88.004	1	46	1
88.038	1	46	1
94.016	1	46	1
94.039	1	46	1
94.091	1	46	1
94.128	1	46	1

Specimen	***Sex***	***Age***	***Ancestry***
94.152	1	46	1
96.042	1	46	1
96.104	1	46	1
96.217	1	46	1
96.241	1	46	1
97.062	1	46	1
97.195	1	46	1
88.069	2	46	1
92.144	2	46	1
92.158	2	46	1
92.163	2	46	1
92.168	2	46	1
93.010	2	46	1
93.064	2	46	1
93.132	2	46	1
93.201	2	46	1
93.213	2	46	1
93.216	2	46	1
94.021	2	46	2
94.092	2	46	1
94.146	2	46	1
95.075	2	46	1
96.005	2	46	1
96.016	2	46	1
96.061	2	46	1
96.124	2	46	1
30.93	2	46	1
12.98	2	46	1
87.078	1	47	1
92.020	1	47	1
93.047	1	47	1
95.096	1	47	1
95.122	1	47	1

Specimen	*Sex*	*Age*	*Ancestry*
96.026	1	47	1
96.168	1	47	1
87.028	2	47	1
88.028	2	47	1
88.039	2	47	1
89.049	2	47	1
93.044	2	47	1
94.012	2	47	1
94.014	2	47	1
94.119	2	47	1
95.175	2	47	1
95.186	2	47	1
95.193	2	47	1
96.012	2	47	1
96.081	2	47	1
96.220	2	47	1
96.253	2	47	1
97.063	2	47	1
97.113	2	47	1
97.137	2	47	1
97.143	2	47	1
98.094	2	47	1
12.88	2	47	1
01.100a	2	47	1
88.021	1	48	1
88.121	1	48	1
92.043	1	48	1
94.190	1	48	1
95.031	1	48	1
95.083	1	48	1
97.230	1	48	1
87.007	2	48	1
87.130	2	48	2

Specimen	*Sex*	*Age*	*Ancestry*
88.055	2	48	1
88.126	2	48	1
89.098	2	48	1
92.147	2	48	1
92.174	2	48	1
93.062	2	48	1
93.152	2	48	1
94.032	2	48	1
94.041	2	48	1
95.110	2	48	1
95.119	2	48	1
95.124	2	48	1
95.153	2	48	1
95.204	2	48	1
95.226	2	48	1
96.088	2	48	1
96.128	2	48	2
96.199	2	48	1
96.228	2	48	1
97.002	2	48	1
97.042	2	48	1
97.133	2	48	1
97.174	2	48	4
97.226	2	48	1
87.019	1	49	1
88.060	1	49	1
88.064	1	49	1
89.004	1	49	1
93.008	1	49	1
93.137	1	49	1
94.201	1	49	1
96.082	1	49	1
96.084	1	49	1

Specimen	*Sex*	*Age*	*Ancestry*
97.001	1	49	1
97.068	1	49	1
97.223	1	49	1
87.089	2	49	1
87.126	2	49	1
87.129	2	49	1
88.003	2	49	1
88.019	2	49	1
88.117	2	49	1
88.130	2	49	1
89.036	2	49	1
92.074	2	49	1
92.076	2	49	1
93.136	2	49	1
94.177	2	49	1
94.186	2	49	1
95.037	2	49	1
95.113	2	49	1
95.164	2	49	1
96.107	2	49	1
96.226	2	49	1
96.243	2	49	1
97.015	2	49	1
97.027	2	49	1
97.064	2	49	1
97.204	2	49	1
98.043	2	49	1
98.085	2	49	1
98.088	2	49	1
10.88	2	49	1
96.19f	2	49	1
88.128	1	50	1
93.191	1	50	1

Specimen	*Sex*	*Age*	*Ancestry*
96.141	1	50	1
86.094	2	50	1
87.020	2	50	1
88.009a	2	50	2
88.056	2	50	1
88.066	2	50	1
93.023	2	50	1
93.085	2	50	1
94.060	2	50	1
94.199	2	50	1
95.030	2	50	2
95.069	2	50	1
95.139	2	50	1
95.187	2	50	1
96.184	2	50	1
96.214	2	50	1
96.223	2	50	1
97.039	2	50	1
97.151	2	50	1
97.182	2	50	1
97.236	2	50	1
98.077	2	50	1
01.134a	2	50	2
93.198	1	51	1
93.204	1	51	1
94.065	1	51	1
96.181	1	51	1
97.103	1	51	1
23.88	1	51	1
87.025	2	51	1
88.094	2	51	1
88.148	2	51	1
88.164	2	51	1

Specimen	*Sex*	*Age*	*Ancestry*
89.034	2	51	1
92.083	2	51	1
92.126	2	51	1
93.093	2	51	1
93.156	2	51	1
93.202	2	51	1
94.099	2	51	1
94.143	2	51	1
95.079	2	51	1
95.092	2	51	1
95.216	2	51	1
96.017	2	51	1
96.052	2	51	1
97.018	2	51	1
97.029	2	51	2
97.035	2	51	1
97.170	2	51	1
97.171	2	51	1
97.178	2	51	1
97.203	2	51	1
98.040	2	51	1
98.090	2	51	1
4.89	2	51	1
88.145	1	52	1
89.028	1	52	1
95.120	1	52	1
95.173	1	52	1
96.123	1	52	1
97.183	1	52	1
98.062	1	52	1
99.29f	1	52	1
87.011a	2	52	1
87.012	2	52	1

Specimen	*Sex*	*Age*	*Ancestry*
87.093	2	52	1
87.113	2	52	1
88.104	2	52	1
93.014	2	52	1
93.210	2	52	1
94.025	2	52	1
94.142	2	52	1
94.158	2	52	1
95.048	2	52	1
95.061	2	52	1
96.127	2	52	1
96.265	2	52	1
97.112	2	52	1
97.210	2	52	1
98.023	2	52	1
98.031	2	52	1
98.054	2	52	2
98.070	2	52	1
12.9	2	52	1
88.120	1	53	1
89.101	1	53	1
92.089	1	53	1
93.149	1	53	1
98.029	1	53	1
87.066	2	53	1
87.154	2	53	1
88.006	2	53	1
92.156	2	53	1
94.173	2	53	1
94.197	2	53	1
95.199	2	53	1
96.010	2	53	1
96.090	2	53	1

Specimen	***Sex***	***Age***	***Ancestry***
96.155	2	53	1
96.240	2	53	1
97.050	2	53	1
97.065	2	53	1
97.108	2	53	1
97.110	2	53	1
97.129	2	53	1
11.89	2	53	1
5.93	2	53	1
94.22f	2	53	1
00.20f	2	53	1
96.037	1	54	1
97.128	1	54	1
87.020a	2	54	1
87.029a	2	54	1
87.040	2	54	1
87.064	2	54	1
88.001	2	54	1
88.139	2	54	1
89.102	2	54	1
92.039	2	54	1
92.049	2	54	2
92.094	2	54	2
92.097	2	54	1
93.117	2	54	1
93.180	2	54	1
93.186	2	54	1
94.017	2	54	1
94.080	2	54	1
94.090	2	54	1
94.098	2	54	1
94.114	2	54	1
95.020	2	54	1

Specimen	Sex	Age	Ancestry
95.049	2	54	1
95.055	2	54	1
95.215	2	54	1
96.043	2	54	1
96.194	2	54	1
97.071	2	54	1
97.091	2	54	1
97.097	2	54	1
97.214	2	54	1
97.235	2	54	1
98.079	2	54	1
27.9	2	54	1
87.076	1	55	1
87.098	1	55	1
88.042	1	55	1
88.119	1	55	1
89.074	1	55	1
94.084	1	55	1
96.029	1	55	1
96.054	1	55	1
97.188	1	55	1
87.071	2	55	1
87.105	2	55	1
87.133	2	55	1
89.064	2	55	1
92.140	2	55	1
92.146	2	55	1
93.060	2	55	1
93.094	2	55	1
93.125	2	55	1
94.053	2	55	1
95.027	2	55	1
95.202	2	55	1

Specimen	*Sex*	*Age*	*Ancestry*
96.053	2	55	1
96.151	2	55	1
97.047	2	55	1
98.074	2	55	1
1.82	2	55	1
4.87	2	55	1
1.92	2	55	2
36.93	2	55	1
39.93	2	55	1
4.96	2	55	1
87.142	1	56	1
88.082	1	56	1
93.013	1	56	1
93.130	1	56	1
94.063	1	56	1
95.025	1	56	1
87.041	2	56	1
87.047	2	56	1
87.083	2	56	1
88.085	2	56	1
88.109	2	56	1
89.052	2	56	1
92.154	2	56	1
93.011	2	56	1
93.029	2	56	1
93.082	2	56	1
93.197	2	56	1
95.046	2	56	1
95.128	2	56	1
95.211	2	56	1
96.022	2	56	1
96.071	2	56	1
96.112	2	56	1

Specimen	*Sex*	*Age*	*Ancestry*
96.118	2	56	1
96.120	2	56	1
96.183	2	56	1
96.203	2	56	1
96.206	2	56	1
96.242	2	56	1
97.032	2	56	1
97.154	2	56	1
97.197	2	56	1
98.051	2	56	1
14.88	2	56	1
10.95	2	56	1
88.047	1	57	1
89.072	1	57	1
94.138	1	57	1
95.184	1	57	1
87.016a	2	57	1
87.040a	2	57	1
87.062b	2	57	1
92.127	2	57	1
93.077	2	57	1
94.107	2	57	1
94.178	2	57	1
95.159	2	57	1
95.185	2	57	1
96.113	2	57	1
96.165	2	57	1
97.083	2	57	1
97.100	2	57	1
4.99	2	57	1
95.227	1	58	1
97.180	1	58	1
98.030	1	58	1

Specimen	*Sex*	*Age*	*Ancestry*
88.002	2	58	1
88.125	2	58	1
89.001	2	58	1
89.027	2	58	1
92.050	2	58	1
94.055	2	58	1
95.088	2	58	1
96.044	2	58	1
97.140	2	58	1
98.033	2	58	1
98.080	2	58	1
7.87	2	58	1
18.91	2	58	1
87.043	1	59	1
89.025	1	59	1
95.161	1	59	1
96.008	1	59	1
96.177	1	59	1
96.252	1	59	1
97.006	1	59	1
97.142	1	59	1
97.146	1	59	1
86.091	2	59	1
87.012a	2	59	1
87.074	2	59	1
87.094	2	59	1
87.124	2	59	1
88.083	2	59	1
89.029	2	59	1
89.076	2	59	1
93.035	2	59	1
93.203	2	59	1
94.004	2	59	1

Specimen	*Sex*	*Age*	*Ancestry*
94.028	2	59	1
94.031	2	59	1
96.149	2	59	1
96.164	2	59	1
97.054	2	59	1
97.061	2	59	1
97.089	2	59	1
97.099	2	59	1
97.212	2	59	1
01.37f	2	59	1
87.001p	1	60	1
93.185	1	60	1
95.146	1	60	1
95.182	1	60	1
96.009	1	60	1
98.044	1	60	1
87.003a	2	60	1
87.003p	2	60	1
89.084	2	60	2
92.082	2	60	1
92.170	2	60	1
93.135	2	60	1
95.093	2	60	1
95.220	2	60	1
96.089	2	60	1
96.153	2	60	1
96.182	2	60	1
01.15f	2	60	1
87.060b	1	61	1
88.115	1	61	1
88.153	1	61	1
94.088	1	61	1
96.137	1	61	1

Specimen	*Sex*	*Age*	*Ancestry*
96.256	1	61	1
87.005a	2	61	1
87.051a	2	61	1
88.091	2	61	1
89.054	2	61	1
92.034	2	61	2
92.047	2	61	1
92.167	2	61	1
92.173	2	61	1
93.124	2	61	2
93.181	2	61	1
94.049	2	61	1
95.101	2	61	1
95.194	2	61	1
96.014	2	61	1
96.077	2	61	1
98.010	2	61	1
29.99	2	61	1
96.078	1	62	1
96.106	1	62	1
96.178	1	62	1
6.92	1	62	1
86.087	2	62	1
87.058	2	62	1
87.060A	2	62	1
87.072	2	62	1
88.059	2	62	1
89.031	2	62	1
95.167	2	62	1
96.013	2	62	1
97.190	2	62	1
3.83	2	62	1
20.95	2	62	1

Specimen	*Sex*	*Age*	*Ancestry*
2.99	2	62	1
92.092	1	63	1
86.085	2	63	1
87.001a	2	63	1
87.014	2	63	1
87.034a	2	63	1
87.041a	2	63	1
87.057a	2	63	1
87.159	2	63	1
88.063	2	63	1
89.086	2	63	1
92.086	2	63	1
93.021	2	63	1
94.007	2	63	1
94.034	2	63	1
94.073	2	63	1
94.100	2	63	1
95.214	2	63	1
96.119	2	63	1
96.140	2	63	1
97.016	2	63	1
97.169	2	63	1
98.034	2	63	1
11.94	2	63	1
87.140	1	64	1
93.122	1	64	1
95.209	1	64	1
95.230	1	64	1
97.106	1	64	1
86.079a	2	64	1
87.019a	2	64	1
87.032a	2	64	1
88.169	2	64	1

Specimen	*Sex*	*Age*	*Ancestry*
89.051	2	64	1
93.009	2	64	1
93.214	2	64	1
95.056	2	64	1
95.191	2	64	2
97.127	2	64	1
97.175	2	64	1
87.110	1	65	1
88.163	1	65	1
89.045	1	65	1
92.138	1	65	1
86.074a	2	65	1
87.018a	2	65	1
87.030	2	65	1
87.039b	2	65	1
88.152	2	65	1
89.003	2	65	1
92.019	2	65	1
92.036	2	65	1
93.089	2	65	1
93.098	2	65	1
93.206	2	65	1
94.043	2	65	1
95.130	2	65	1
96.087	2	65	1
96.111	2	65	1
96.231	2	65	1
96.255	2	65	1
97.094	2	65	1
97.124	2	65	1
97.206	2	65	4
98.092	2	65	1
6.91	2	65	1

Specimen	*Sex*	*Age*	*Ancestry*
96.085	1	66	1
97.163	1	66	1
1.96	1	66	2
3.99	1	66	1
87.043a	2	66	1
87.044a	2	66	1
92.072	2	66	1
93.076	2	66	2
93.081	2	66	1
93.101	2	66	1
95.176	2	66	1
95.222	2	66	1
97.043	2	66	1
97.090	2	66	1
88.002a	1	67	1
88.075	1	67	1
88.077	1	67	1
94.018	1	67	1
94.124	1	67	2
87.070	2	67	1
87.108	2	67	1
88.027	2	67	1
88.043	2	67	1
89.056	2	67	1
92.055	2	67	1
92.075	2	67	1
93.229	2	67	1
94.071	2	67	1
94.129	2	67	1
94.137	2	67	1
97.024	2	67	2
97.187	2	67	1
97.220	2	67	1

Specimen	*Sex*	*Age*	*Ancestry*
7.86	2	67	1
23.94	2	67	1
86.086	1	68	1
87.032	1	68	1
92.070	1	68	1
93.086	1	68	1
94.187	1	68	1
95.044	1	68	1
96.079	1	68	1
11.9	1	68	1
87.024a	2	68	1
87.064a	2	68	2
87.082	2	68	1
89.094	2	68	1
92.129	2	68	1
92.157	2	68	1
94.174	2	68	1
95.058	2	68	1
95.196	2	68	1
96.193	2	68	1
97.158	2	68	1
98.028	2	68	1
98.072	2	68	1
24.88	2	68	1
3.91	2	68	1
31.93	2	68	2
00.18f	2	68	1
92.044	1	69	1
92.114	1	69	1
95.086	1	69	3
96.198	1	69	1
86.076a	2	69	1
87.051	2	69	1

Specimen	*Sex*	*Age*	*Ancestry*
88.018	2	69	1
89.026	2	69	1
89.035	2	69	1
89.090	2	69	1
92.021	2	69	1
92.054	2	69	1
92.118	2	69	1
92.122	2	69	1
93.012	2	69	1
94.123	2	69	1
95.145	2	69	1
95.192	2	69	1
96.069	2	69	1
96.103	2	69	1
96.105	2	69	1
97.116	2	69	1
98.045	2	69	1
6.87	2	69	2
96.158	1	70	1
97.079	1	70	1
00.28f	1	70	1
87.016	2	70	1
88.016	2	70	1
88.037	2	70	1
88.072	2	70	1
89.017	2	70	1
89.018	2	70	1
89.046	2	70	1
93.158	2	70	1
94.083	2	70	1
94.153	2	70	1
95.018	2	70	1
95.078	2	70	1

Specimen	*Sex*	*Age*	*Ancestry*
96.130	2	70	1
97.069	2	70	1
98.032	2	70	1
8.91	2	70	1
12.91	2	70	1
92.041	1	71	1
92.123	1	71	1
1.88	1	71	1
7.95	1	71	1
87.001	2	71	1
94.193	2	71	1
96.139	2	71	1
96.236	2	71	2
87.013	1	72	1
96.200	1	72	1
87.002a	2	72	1
87.046	2	72	1
87.047a	2	72	1
87.048	2	72	1
87.096	2	72	1
87.151	2	72	1
88.068	2	72	1
88.084	2	72	1
88.150	2	72	1
89.013	2	72	1
92.113	2	72	1
93.109	2	72	1
93.114	2	72	1
93.154	2	72	1
94.140	2	72	1
94.163	2	72	1
95.168	2	72	1
96.095	2	72	1

Specimen	*Sex*	*Age*	*Ancestry*
97.202	2	72	1
89.057	1	73	1
94.030	1	73	1
95.002	1	73	1
96.150	1	73	1
87.002	2	73	1
87.097	2	73	1
87.101	2	73	1
89.077	2	73	1
93.031	2	73	1
93.155	2	73	1
93.172	2	73	1
94.074	2	73	1
95.013	2	73	1
95.016	2	73	1
97.066	2	73	1
1.81	2	73	1
22.93	2	73	1
45.93	2	73	1
19.99	2	73	1
87.008a	2	74	1
87.025a	2	74	1
87.026a	2	74	1
87.042a	2	74	1
87.109	2	74	1
92.087	2	74	1
92.178	2	74	1
94.009	2	74	1
96.034	2	74	1
96.035	2	74	1
96.244	2	74	1
97.055	2	74	1
97.198	2	74	1

Specimen	*Sex*	*Age*	*Ancestry*
97.218	2	74	1
88.012	1	75	1
94.015	1	75	1
94.024	1	75	1
94.157	1	75	1
92.120	2	75	1
94.159	2	75	1
95.034	2	75	1
95.212	2	75	1
88.081	1	76	2
93.069	1	76	1
94.181	1	76	1
97.093	1	76	1
20.91	1	76	1
93.007	2	76	1
94.167	2	76	1
95.003	2	76	1
95.132	2	76	1
98.005	2	76	2
10.87	2	76	1
23.93	2	76	1
92.106	1	77	1
96.055	1	77	1
96.091	1	77	1
98.014	1	77	1
87.036	2	77	1
93.033	2	77	1
94.037	2	77	1
94.082	2	77	1
96.251	2	77	1
97.040	2	77	1
98.009	2	77	1
25.91	2	77	1

Specimen	*Sex*	*Age*	*Ancestry*
88.046	1	78	1
93.153	1	78	1
01.28f	1	78	1
86.077a	2	78	1
87.004a	2	78	1
88.096	2	78	2
88.147	2	78	1
89.042	2	78	1
89.062	2	78	1
92.062	2	78	1
92.159	2	78	1
97.121	2	78	1
22.9	2	78	1
18.93	2	78	1
87.031	1	79	1
88.143	1	79	1
96.129	1	79	1
98.057	1	79	1
87.010a	2	79	1
87.014a	2	79	1
87.029	2	79	1
87.055	2	79	1
93.173	2	79	1
97.080	2	79	1
97.122	2	79	1
1.97	2	79	1
87.104	1	80	1
87.143	1	80	1
95.006	1	80	1
6.93	1	80	1
87.002p	2	80	1
87.021a	2	80	1
87.033a	2	80	1

Specimen	*Sex*	*Age*	*Ancestry*
93.070	2	80	1
94.204	2	80	1
95.009	2	80	1
95.010	2	80	1
95.180	2	80	1
97.086	2	80	1
98.069	2	80	1
87.069	1	81	2
87.131	1	81	1
88.031	1	81	1
95.206	1	81	1
96.148	1	81	1
97.045	1	81	1
97.049	1	81	1
87.031a	2	81	1
93.162	2	81	1
96.093	2	81	1
89.068	1	82	1
87.022a	2	82	1
87.061A	2	82	1
88.058	2	82	1
92.017	1	83	1
95.007	1	83	2
95.123	1	83	1
96.073	1	83	1
87.158	2	83	1
96.098	2	83	1
96.121	2	83	1
97.020	2	83	1
17.97	1	84	1
87.086	2	84	1
88.023	2	84	1
93.059	2	84	1

Specimen	*Sex*	*Age*	*Ancestry*
93.223	2	84	1
97.184	2	84	1
15.93	2	84	2
95.127	1	85	1
96.074	1	85	1
01.27f	1	85	1
93.020	2	85	1
97.041	2	85	1
97.156	2	85	1
88.014	1	86	1
95.111	2	86	1
97.199	2	86	1
00.40f	2	86	1
96.056	1	87	1
96.176	1	87	1
98.022	1	87	1
89.097	2	87	1
94.150	2	87	1
2.85	2	87	1
87.035	1	89	1
92.104	1	89	1
97.193	2	89	1
98.067	2	89	1
21.94	2	89	1
87.017a	2	90	1
87.045	2	90	1
94.192	1	91	1
95.148	1	92	1
87.006a	2	92	1
87.055a	2	92	1
97.215	1	101	2
4.94	2	101	1

Appendix B

Data by Specimen sorted by age and sex

Specimen	BH	BW	BT	GHS	GHD	MTT	LHF	RHF	L1	L2	L3	L4	R1	R2	R3	R4
95.001	5.74	7.85	1.6				1	1								
92.058	5.64	8	1.79				1	1								
93.227	5.91	7.41	1.36				1	1								
98.011	5.98	6.59	1.47				1	1								
93.067	6.3	6.7	2.2				1	1								
93.143	7.2	9.68	1.56				1	1								
93.150	5.09	6.68	1.04				1	1								
88.141	6.24	7.13	1.06				1	1								
88.034	5.43	7.55	1.54				1	1								
89.012	6.38	8.77	1.5				1	1								
95.094	6.16	8.91	1.19				1	1								
97.034	7.35	7.7	1.13				1	1								
97.232	6.33	9.25	2.01				1	1								
92.067		4.98	2.16				1	1								
93.037	5.67	8.57	1.1				1	1								
92.060	4.88	7.15	2.02				1	1								
87.063	6.24	11.47	1.15				1	1								
92.056	5.19	8.61	1.58				1	1								
93.054	6.2	8.99	1.99				1	1								
89.010	8.39	11.83	1.63				1	1								
96.248	6.43	9.88	1.6				1	1								
88.172	7.75	12.11	1.54				1	1								
92.037	7.77	10.36	2.14				1	1								
93.129	7.98	11.4	1.51				1	1								
95.109	7.68	9.68	1.68				1	1								
94.105	7.43	9.73	1.84				1	1								
89.022	8	10.54	2				1	1								
89.020	6.19	6.98	1.5				1	1								
97.087	6.63	11.75	1.72				1	1								
98.036	9.38	11.58	2.02				1	1								
88.158	6.69	13.25	1.34				1	1								
89.082	6.22	9.74	1.9				1	1								
97.056	7.89	11.19	1.62				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
89.080	8.25	13	1.9				1	1								
94.094	8.61	12.9	1.51				1	1								
88.020	7.37	12.87	1.66				1	1								
89.048	8.26	10.55	1.78				1	1								
92.115	8.5	12.77	2.05				1	1								
93.003	7.9	11.92	1.92				1	1								
95.040	8.93	14.13	1.39				1	1								
96.211	6.52	13.35	1.51				1	1								
93.170	10.08	15.41	2.03				1	1								
88.156	7.95	14.27	2.13				1	1								
89.008	11.37	16.71	1.9				1	1								
92.027	8.2	16.04	1.37				1	1								
88.122	8.56	13.76	2.22				1	1								
96.207	10.71	14.03	1.86				1	1								
94.045	7.73	13.85	1.04				1	1								
94.147	7.91	16.73	1.52				1	1								
93.048	8.65	12.16	1.3				1	1								
01.110a	7.46	14.69	1.65				1	1								
92.029	8.31	14.72	1.06				1	1								
88.009	9.06	15.33	2.25				1	1								
88.053	9.5	12.85	1.7				1	1								
88.099	11.54	17.74	1.91				1	1								
94.064	10.09	18.32	2.73				1	1								
92.100	8.32	15.6	1.6				1	1								
92.150	9.53	16.26	1.95				1	1								
98.095	10.57	11.12	1.47				1	1								
87.061	9.75	18.52	3.08				1	1								
88.079	11.47	13.3	3.49				1	1								
88.155	8.35	14.29	1.86				1	1								
92.028	10.66	18.27	2.36				1	1								
92.063	10.62	14.99	2.61				1	1								
92.141	9.65	15.05	2.11				1	1								
92.151	9.67	15.75	2.45				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
93.195	8.98	15.09	1.61				1	1								
96.092	12.23	15.55	1.81				1	1								
96.201	12.36	15.12	2.01				1	1								
96.221	9.65	15.94	1.54				1	1								
93.118	8.34	15.94	1.44				1	1								
94.047	7.45	13.84	1.37				1	1								
94.077	8.78	13.6	1.84				1	1								
95.082	8.05	22.45	2.26				1	1								
95.157	11.21	15.97	2				1	1								
96.115	9.31	13.76	1.95				1	1								
98.012	7.78	15.41	1.74				1	1								
87.087	9	16.3	2.19				1	1								
88.151	10.9	17.46	2.03				1	1								
88.154	10.47	16.79	2.2				1	1								
89.011	11.9	16.29	2.12				1	1								
93.051	9	14.7	3				1	1								
94.135	11.55	19.81	2.31				1	1								
95.155	10.22	17.14	1.82				1	1								
96.156	9.67	14.7	2.36				1	1								
98.050	8.92	18.03	2.15				1	1								
87.162	9.63	16.59	1.69				1	1								
92.112	8.89	13.89	1.99				1	1								
93.175	10.93	15.98	2.38				1	1								
93.221	11.29	16.07	2.23				1	1								
95.085	8.97	13.05	1.88				1	1								
95.217	8.94	16.8	1.77				1	1								
87.148	12.84	21.71	2.07				1	1								
87.153	10.67	19.11	2.33				1	1								
89.065	10.82	16.51	1.98				1	1								
93.174	8.58	18.81	2.47				1	1								
94.079	10.55	14.6	2.9				1	1								
94.095	10.54	18.53	2.04				1	1								
94.195	9.91	16.41	2.11				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.067	11.28	16.71	1.94				1	1								
97.096	10.32	14.84	1.58				1	1								
97.155	11.05	17.11	1.8				1	1								
97.227	9.58	14.84	2.57				1	1								
93.068	8.36	15.64	2.38				1	1								
93.138	9.19	16	1.68				1	1								
93.226	9.94	16.05	2				1	1								
94.141	8.81	13.9	1.81				1	1								
94.185	9.34	14.03	1.7				1	1								
95.115	12.11	17.47	2.22				1	1								
89.024	10.31	16.58	2.1				1	1								
89.091	12.2	18.64	2.52				1	1								
92.079	11.68	17.57	2.4				1	1								
93.049	9.3	18.3	2.09				1	1								
93.078	11.23	16.87	2.42				1	1								
94.076	10.19	15.55	2.31				1	1								
95.080	10.62	17.48	2.88				1	1								
96.058	10.41	17.2	1.89				1	1								
96.059	8.11	18.18	1.23				1	1								
96.116	9.61	16.34	2.8				1	1								
96.133	10.82	16.23	1.9				1	1								
96.180	10.81	17.18	1.72				1	1								
96.250	10.75	14.3	2				1	1								
97.125	10.86	18.31	2.05				1	1								
97.177	9.49	16.49	1.91				1	1								
98.058	8.22	19.32	1.9				1	1								
87.073	6.46	18.27	1.26				1	1								
94.011	8.1	14.46	1.37				1	1								
94.162	7.63	17.03	1.71				1	1								
94.184	11.26	15.05	2.4				1	1								
94.194	8.63	14.4	1.9				1	1								
96.136	8.64	13.14	1.59				1	1								
87.050	7.92	17.34	2.11				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.008	12.28	20.7	2.31				1	1								
92.078	10.9	16.46	2.9				1	1								
93.230	10	21	2.21				1	1								
94.072	9.59	16.24	2.15				2	1	1	2	1	1				
94.093	10.85	21.2	2				1	1								
94.101	12.35	20.7	2.19				1	1								
94.110	10.74	17.21	2.19				1	1								
95.066	14.07	17.89	2.11				1	1								
95.068	10.91	16.11	2.06				1	1								
96.030	10.9	20.03	1.51				1	1								
96.216	12.32	19.84	2.21				1	1								
97.209	12.27	18.39	2.09				1	1								
98.025	11.02	20.73	2.54				1	1								
98.046	9.93	17.48	1.67				1	1								
98.048	11.29	17.59	1.89				1	1								
87.018	8.95	14.48	1.51				1	1								
87.075	10.32	16.86	2.2				1	1								
93.171	10.02	15.81	1.87				1	1								
93.205	8.53	15.53	1.21				1	1								
95.038	8.85	18.57	1.42				1	1								
96.215	8.2	16.73	1.41				1	1								
98.068	8.64	17.75	2.06				1	1								
87.023	11.36	21.94	3.67				1	1								
87.049	10.27	19.34	2.28				1	1								
87.117	11.84	23.29	2.07				1	1								
87.161	8.77	17.25	2				2	1	1	2	2	1				
88.087	10.38	19.16	2.12				1	1								
89.069	11.34	17.16	3.64				1	1								
92.035	9.74	19.69	2.13				1	1								
92.048	11.5	17.3	1.89				1	1								
93.147	12	18.5	2.39				1	1								
94.006	9.76	17.84	1.96				1	1								
95.026	12.91	20.2	1.81				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
95.045	11	17.79	2.33				2	1	1	2	2	1				
95.091	9.16	19.98	1.8				2	1	1	1	2	1				
95.104	10.11	15.66	2.56				1	1								
96.159	10.72	21.18	2.23				1	1								
96.171	11.03	17.48	2.21				1	1								
96.208	12.68	21.08	2.76				1	1								
97.044	10.08		2.48				2	3	2	3	3	2				
97.046	10.33	17.59	2.08				1	1								
97.205	8.53	18.88	2.26				1	1								
93.072	8.21	13.83	1.19				1	1								
95.147	10.37		1.86	41.09	34.96	3.07	2	3	2	3	3	1				
95.149	9.63	13.48	2.47				1	1								
87.084	10.76	23.41	2.66				1	1								
89.006	11.57	17.59	2.63				1	1								
89.019	12.35	20.62	2.93				1	1								
92.119	12.29	19.38	2.03				1	2					1	3	3	1
93.041	8.91	19.3	1.68				1	1								
93.127	9.61	17.03	1.97				1	1								
93.128	11.46	20.32	1.93				1	1								
94.035	10.54		2.12				3	3								
95.032	11.03	22.66	2.89	49.65	41.11	4.27	1	2					3	3	2	1
95.039	11.66	19.58	2.52				1	1								
96.038	12.18	18.85	1.92				1	1								
96.066	10.09	17.54	1.35				1	1								
96.147	10.52	20.14	1.7				1	1								
97.088	8.62	21.14	1.28				1	2					2	2	2	1
98.056	11.2	18.56	2.73				1	1								
87.112	8.93	15.78	1.65				1	1								
95.090	12	15.64	1.7				1	1								
87.059	10.82	21.07	2.34	46.46	40.01	3.23	2	2	3	3	3	2	2	2	1	1
87.122	10.53	22.96	1.95				1	1								
87.149	12.51	20.15	1.92				1	1								
88.025	11.06	22.34	1.47				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.074	12.31		2.34				1	1								
88.090	11.24	19.03	1.97				1	1								
88.102	11.88	19.48	2.39				1	1								
88.166	9.55	19.93	2.65				1	1								
92.068	9.21	17.55	2.58				1	1								
92.136	11.73	18.08	2.16				1	1								
93.140	11.58	19.09	2.53				1	1								
93.159	11.07	21.35	2.35				1	1								
93.222	9.86	20.14	2.04				1	1								
94.062	9.12	21.31	1.78				1	1								
94.151	10.2	15.75	1.84				1	1								
94.170	9.98	18.09	2.3				1	1								
95.151	12.17	16.14	2.48				1	2					1	2	2	1
96.135	10.5	20.98	1.91				1	1								
96.257	11.14	20.11	1.96				1	1								
98.038	10.85	18.02	2.72				1	1								
87.092	9.12	16.45	1.72				1	1								
89.099	9.71	21.32	1.91	44.76	40.11	2.33	2	2	3	3	3	1	3	3	3	1
92.066	9.44		2.44	44.67	39.31	2.68	3	3								
92.135	8.33	16.76	2.45				1	1								
94.182	8.55	16.25	1.22				1	1								
94.202	8.88	15.39	1.84				1	1								
97.076	8.82	16.44	1.62				1	1								
87.164	11.66	24.68	2.62				1	1								
88.017	10.44	17.27	1.57				1	1								
92.179	11.66	22.7	2				1	1								
93.017	11.74	19.92	2.34				1	1								
93.066	10.29	21.7	2.74				1	1								
94.029	11.76	20.91	1.75				1	1								
94.086	9.65	20.35	1.75				1	1								
94.122	12.23	21.14	2.18				1	1								
95.126	10.88	16.4	2.1				1	1								
95.150	11.04	17.42	2.04				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
95.162	12.07	17.76	1.97				1	1								
95.203	9.25	18.86	1.9				1	1								
95.210	10.13	21.12	2.22				1	1								
96.070	10.06	16.21	1.64				1	1								
96.134	9.89	19.76	1.83				2	1	3	3	2	2				
96.160	9.36	18.29	2.23				1	1								
97.007	8.33	19.08	1.95				2	2	3	3	3	1	3	3	3	1
97.117	10.37	21.87	1.81				1	1								
97.194	9.71	24.18	1.78				1	1								
95.057	7.83	16.08	1.86				1	1								
96.247	9.31	18.48	1.44				1	1								
87.021	12.82	21.33	2.59				1	1								
87.027	13.55		2.7				3	1								
87.058	10.11	21.95	2.38				1	1								
87.146	10.94	25.68	2.77				1	1								
88.080	7.26	21.56	1.1				1	1								
88.131	10.59	18.58	1.86				1	1								
89.044	11.02	21.37	2.57				2	1	3	3	3	1				
92.071	10.11		2.61	38.85	30.65	4.1	3	3								
92.130	10.79	20.4	2.07				1	1								
93.075	10.12	17.45	2.18				1	1								
93.080	11.15	20.32	1.88				1	1								
94.069	10.26	19.03	2.21				1	1								
95.154	11.07	17.11	2.41				1	1								
95.171	10.14	20.31	2.56				1	1								
96.015	12.87	19	1.96				1	1								
96.132	9.95		2.1				1	1								
97.011	9.09	15.67	1.96				1	1								
97.030	9.09	17.81	1.84				1	1								
97.037	10.61	18.7	1.36				1	1								
98.064	10.22	21.21	2.3				1	1								
89.083	9.38	16.7	3				1	1								
93.219	8.25		2.02	40.26	34.68	2.79	2	3	2	3	3	2				

Specimen	***BH***	***BW***	***BT***	***GHS***	***GHD***	***MTT***	***LHF***	***RHF***	***L1***	***L2***	***L3***	***L4***	***R1***	***R2***	***R3***	***R4***
94.208	8.43	15	1.91				1	1								
95.213	7.75	16.86	1.8				1	1								
96.096	10.8	15.98	2.08				1	1								
97.221	7.6	13.85	1.7				1	1								
88.029	13.52	21.61	1.81				1	2					1	3	3	1
88.106	11.78	18.25	3.49				1	1								
88.110	11.66	22.09	1.86				1	1								
89.059	9.13	18.99	2.95				1	1								
89.071	10.05	19.77	2.47				1	1								
89.088	12.63	20.6	2.54				1	1								
92.073	11.6	20.33	2.46				1	1								
93.040	12.3	19.08	2.32				1	1								
93.142	8.14	23.74	2.1	41.46	34.78	3.34	2	2	3	3	3	2	2	3	3	2
93.168	10.24	18.76	2.21				2	1	3	3	3	2				
94.023	10.83	23.26	2.43				1	1								
94.059	11.74	20.72	1.4				1	1								
95.106	11.55	17.06	1.94				1	1								
95.189	8.67	22.65	2.32	55.81	46.98	4.42	1	1								
96.083	10.52	20.28	2.89				1	1								
96.101	9.95	19.57	1.51				1	1								
97.168	9.65	14.81	1.45				1	1								
97.213	11.35	16.76	1.84				1	1								
98.008	11.12	19.71	2.02				1	1								
98.061	9.36		2.01				2	3	3	3	2	2				
87.157	8.16	17.62	2.08				1	1								
88.036	8.71	15.59	1.88				1	1								
88.057	8.22	17.7	1.78				1	1								
88.073	10.79	15.66	2.72				1	1								
88.108	8.84	17.76	2.1				1	1								
93.043	10.05	19.01	2.33				1	1								
94.168	9.69	18.4	1.6				1	1								
95.071	7.2	18.18	2.23				1	1								
96.011	9.06	17.94	1.83				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
01.105a	10.85	15.78	1.85				1	1								
87.120	11.32	19.55	2.31				1	1								
88.067	11.06	25.48	2.92				1	1								
89.009	11.9	22.08	1.12				1	1								
89.033	10.17	18.9	3				1	1								
89.079	9.24		2.34	43.94	39.62	2.16	3	3								
89.100	11.71	16.46	2.8				1	1								
92.064	11.41	15.43	2.19				1	1								
92.109	11.88	20.15	2.36				1	1								
92.161	11.08		2.09				3	1								
93.053	9.8	19.82	1.7				2	2	3	3	3	1	3	3	3	1
94.033	9.67	21.73	1.83				1	1								
94.044	10.11	18.2	2.18				1	1								
94.078	9.7	19.7	2.81				1	1								
94.116	8.73		2.44	38.42	31.51	3.46	3	3								
94.189	10.54	18.08	2.92				1	1								
94.200	7.12	16.4	1.87				1	1								
95.152	8.62	21.58	1.96				1	1								
95.163	9.31	20.61	2.14				1	1								
96.142	10.94	18.28	2.33				1	1								
96.192	12.32	20.87	1.27				1	1								
96.246	11.09	20.7	2.26				1	1								
96.261	14.71	19.41	1.81				1	1								
97.023	10.04	18.59	2.54				1	1								
97.120	9.82	22.47	1.91				1	1								
97.192	10.77	20.71	1.74				1	1								
98.059	7.98	17.69	1.22				2	2	1	3	2	1	2	3	3	1
87.123	10.05	16.96	3.03				1	1								
88.174	9	15.92	1.57				1	1								
92.025	8.8	17.71	1.14				2	1	3	3	3	2				
92.128	9.04	18.91	2.27				1	1								
94.042	8.33	17.45	1.71				2	2	2	3	3	3	2	3	3	3
94.130	9.29	14.97	2.01				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
95.011	10.55	16.16	1.05				1	1								
95.052	8.49		1.3	41.99	35.7	3.15	3	3								
98.083	10.04	17.31	2.35				1	1								
87.053	11.11	17.69	2.42				1	1								
87.088	11.39	19.51	1.93				1	1								
87.099	12.11	19.56	2.53				1	1								
87.139	11.77	21.2	2.52				1	1								
88.015	10.43	21.19	2.8				1	1								
88.086	11.68	23.65	2.53	48.8	43.85	2.48	2	2	3	3	3	2	3	3	3	2
88.105	11.56	22.66	3.1		48.5		1	1								
89.073	9.61		2.65	45.99	40.28	2.86	3	3								
89.096	12.27	20.88	2.3				1	1								
92.125	10.22	18.7	1.69				1	1								
92.142	11.7	20.23	3.08				1	2					1	2	2	1
93.036	12.51	20.64	2.89				1	1								
93.087	10.67	20.26	2.29				1	1								
93.100	11.91	22.5	2.44				1	1								
93.113	9.42		1.77				3	2					2	3	3	2
93.131	9.93	18.19	2.78				1	1								
93.146	10.97		1.63				3	2					3	3	3	2
94.038	9.98	21.35	2.19				1	1								
94.169	10.35	21.93	0.89				1	1								
95.041	9.94	23.54	2.03	56.31	46.79	4.76	1	1								
95.076	8.34	17.15	1.64	36.36	30.4	2.98	2	1	2	2	2	1				
95.223	12.84	24.59	1.59	47.15	39.32	3.92	2	2	2	3	3	2	3	3	3	2
96.075	10.07	19.97	1.74				1	1								
96.162	9.31	21.07	2.13				2	1	1	1	1	1				
96.249	9.99	21.45	2.71				1	1								
97.057	8.72	23	2.14				1	1								
97.115	10.86	20.19	1.89				2	2	2	2	3	2	2	3	3	2
98.091	10.65	18.9	1.82				1	1								
87.054	7.51	17.89	1.95	45.17	38	3.59	2	2	2	3	3	2	2	3	3	2
88.114	9.41	18.41	1.51				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
92.038	9.66	17.86	1.96				1	1								
95.022	8.3	18.04	2.16				1	1								
95.131	8.46		2.82	36.96	29.38	3.79	2	3	2	2	1	1				
95.183	8.68	16.01	1.86				1	1								
96.191	7.55	19.9	1.48				1	1								
97.051	9.81	17.3	1.28				1	1								
87.004	10.66		2.93	45.67	38.12	3.78	3	3								
87.065	11.34	22.98	2.94				1	1								
87.134	8.89	24.52	2.6				1	1								
88.026	12.74	22.79	2.21				1	1								
88.062	8.95		2	52.76	45.25	3.76	3	2					2	3	3	1
89.087	10.55	21.37	2.01				1	1								
92.053	10.21	18.58	1.98				2	1	2	3	3	2				
92.103	11.73	18.86	2.89				1	1								
92.131	9.19	19.91	1.82				1	1								
92.137	10.48		2.27	46.84	40.85	3	3	2					3	3	3	2
92.152	11.08	21.53	2.34				1	1								
92.155	10	21.44	2.13				1	1								
93.006	10.09	20.55	2.09				1	1								
93.110	10.91	25.02	2.08	54.37	47.3	3.54	2	2	3	3	3	2	3	3	3	2
93.126	9		1.86				3	2					2	3	3	1
93.207	10.86	19.36	2.5				1	1								
94.067	9.79	19.89	2.41				1	1								
94.104	10.06	25.42	0.8				1	1								
95.231	12.37	19.72	2.58				1	1								
96.100	11.27	20.54	2.7				1	2					1	1	1	1
97.134	10.05	18.63	2.22				1	1								
98.076	9.73	18.97	2.2				1	1								
99.35f	9.87	19.49	1.84	44.41	38.29	3.06	1	3								
87.107	11.33		2.86	41.06	33.53	3.77	2	2	2	3	3	2	3	3	3	2
89.007	9.23	17.28	1.79				1	1								
92.061	9.2	20.68	1.47				1	2					3	3	3	2
92.090	8.53		2.45	37.51	30.82	3.35	2	2	3	3	3	2	3	3	3	2

Specimen	***BH***	***BW***	***BT***	***GHS***	***GHD***	***MTT***	***LHF***	***RHF***	***L1***	***L2***	***L3***	***L4***	***R1***	***R2***	***R3***	***R4***
95.005	10.4	16.72	1.7				1	1								
95.015	8.11	15.22	1.65				1	1								
95.137	8.72	17.59	1.47				2	1	3	3	3	2				
95.177	8.8	16.59	2.26				1	1								
97.105	10.82	16.52	1.66	37.68	30.11	3.79	2	2	2	3	2	1	1	2	1	1
97.222	9.03	14.92	1.89				1	1								
96.5f	8.45	17.8	2.04				1	1								
87.026	13.38	21.04	2.07				1	1								
87.042	10.81	24.07	2.36				1	1								
87.138	11.31	24.58	1.9				1	1								
88.161	11.41	21.15	2.2				1	2					3	3	3	1
92.065	10.91	24.06	2.37				1	1								
92.095	11.64	18.7	2.51				1	1								
92.096	11.24	19.57	2.6				1	1								
92.162	12.17		2.64				1	2					3	3	3	2
93.123	11.13	24.07	2.93				1	1								
93.215	8.8	20.55	2.02				1	1								
93.224	9.91		1.65	48.12	42.61	2.76	3	3								
94.058	12.11	20.58	1.78				1	1								
95.158	11.38	20.17	1.67	46.89	41.02	2.94	2	1	3	3	3	2				
95.179	10.61	19.49	2.74				1	1								
96.020	10.39	19.77	2.27				1	1								
97.082	12.14	19.03	3.12				1	1								
97.132	9.14	20.43	2.53				1	1								
97.139	8.54	20.23	2.44				1	1								
98.049	10.42	19.46	2.09				1	1								
87.052	8.54	16.85	2.09				1	2					2	3	2	2
92.164	10.07	17.92	2.06	50.95	43.42	3.77	2	1	1	2	2	1				
92.181	10.17	18.21	2.21				1	1								
96.048	8.37	18.46	1.8				1	1								
96.099	8.75	18.64	1.72	37.39	33.52	1.94	2	2	3	3	3	1	3	3	2	2
96.152	10.53	19.03	2.16				1	1								
87.038	9.64	18.03	2.08				2	1	2	3	3	2				

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
87.079	10.82	20.6	2.72				1	1								
88.020	10.72	20.15	2.21				1	1								
88.111	9.86	20.85	1.49				1	1								
88.118	12	20.87	1.29				1	2					3	3	3	2
92.052	11.3	19.59	2.11	51.06	45.36	2.85	2	2	1	3	3	3	1	1	1	1
92.093	12.66		2.1	40.36	34.23	3.07	2	3	3	3	3	1				
93.038	10.6	22.15	2.18				1	1								
93.144	12.78	21.56	2.59	56.91	49.94	3.49	1	2					2	3	3	2
94.019	9.75		2.01	51.34	43.22	4.06	2	3	3	3	3	1				
94.121	9.36	21.72	2.24				1	1								
95.004	10.83	20.21	1.7				2	2	2	3	3	2	2	3	3	1
95.017	10.98		2.65	48.74	43.32	2.71	3	2					3	3	3	2
95.019	11.07		2.22	52.25	47	2.63	3	3								
95.043	10.07	22.75	2.42				1	1								
95.095	10.17	17.6	2.9				1	1								
95.108	10.88		2.05				1	2					2	3	3	3
95.133	10.13	20.35	2.41				1	1								
96.024	11.23	20.43	2				1	1								
96.031	11.51	22.29	1.74				1	1								
96.154	12.12	21.21	1.5				1	1								
96.260	11.11	22.14	2.15				1	1								
97.131	11.34	22.77	2.75				1	1								
88.123	9.93	16.43	1.94				1	1								
92.057	9.94	17.36	1.72				1	1								
94.136	7.94	16.43	1.81	35.13	29	3.07	2	2	3	3	3	2	2	3	3	2
94.191	11.22	15.24	1.91				1	1								
95.098	9.32	20.52	2.11	49.38	40.85	4.27	2	2	2	2	3	1	2	2	3	1
97.167	9.13	15.38	1.29				1	1								
87.022	11.48	21.65	2.04				1	1								
87.125	10.94		1.84				2	2	3	3	3	1	3	3	3	1
87.141	11.27	19.85	2.65				1	1								
87.163	10.77	24.07	2.34				1	1								
88.010	9.76	18.6	2.31				1	2					3	3	3	1

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.071	11.02		1.78	37.33	31.53	2.9	3	3								
88.142	12.08	19.27	1.91				1	1								
89.023	9.21	28.1	2.4				1	1								
89.070	13.51		1.46	45.69	39.28	3.21	3	3								
92.059	9.66	20.51	2.07				2	1	3	3	3	1				
92.172	12.53	18.75	1.66				1	1								
93.046	10.73		2.9	43.63	38.09	2.77	2	3	3	3	3	2				
93.151	8.88	21.13	2.45				1	1								
94.160	10.15	21.29	1.9				1	2					1	2	1	1
94.207	12.42	20.63	1.86				1	2					1	2	3	1
95.100	10.39	16.09	1.72				1	1								
95.112	12.72	22.74	2.65				2	1	2	3	2	2				
95.143	8.74	18.53	2.08				1	1								
96.028	10.78	22.07	1.58	48.47	43.26	2.61	2	2	2	3	3	1	2	3	3	2
96.175	10.14		1.85	39.51	33.54	2.99	3	3								
96.212	8.82		1.92				3	3								
96.254	10.27		2.38	47.63	40.66	3.49	3	3								
97.036	10.85	22.3	2.64				2	2	2	3	3	3	3	3	3	2
97.145	11.68	21.09	1.77				1	1								
98.027	12.28	21.2	1.79	46.83	38.76	4.04	2	2	2	3	3	2	2	2	2	2
98.060	10.31		3.05	44.5	33.96	5.27	3	2					3	3	3	2
98.066	11.44	18.48	2.72				1	1								
87.080	8.71	17.12	2.32				1	1								
87.152	8.64	17.64	1.67				1	2					1	2	1	1
89.038	9.2	15.92	1.49				1	1								
89.043	9.09	16.14	1.62				1	1								
89.085	9.45	18.01	2.25				2	2	3	3	3	2	3	3	3	2
93.167	8.43	17.84	2.07				1	2					3	3	3	2
93.220	6.75	17.16	1.23				1	1								
94.166	7.9	16.67	1.93				1	1								
96.234	7.59		1.65	38.47	31.74	3.37	3	3								
87.006	11.9	21.17	2.44				1	1								
87.144	9.65	22.16	2.41				2	1	3	3	3	2				

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.005	11.4		2.08	48.9	41.6	3.65	3	3								
88.097	10.44	22.98	3.15				1	2					3	3	3	2
88.167	11.06	20.35	2.26				1	1								
92.018	12.01	17.17	2.11				1	2					2	3	3	1
92.091	7.96	18.45	2	37.91	31.29	3.31	2	2	3	3	3	1	1	3	2	1
92.124	10.6	21.14	1.54				1	1								
93.004	10.56	20.27	2.6				2	1	1	1	1	1				
93.071	9.08	18.96	2.01				1	1								
93.111	8.3	17.44	2.3				1	1								
93.148	11.98	23.68	2				2	1	1	3	3	1				
94.040	12.86		1.6	45.01	38.54	3.24	3	2					3	3	3	1
94.081	10.68	19.03	2.68				2	1	1	3	3	1				
94.145	11.01	18.81	2.63				1	1								
94.161	11.31	16.82	1.48				1	1								
94.172	9.41	20.64	1.7				1	1								
95.081	9.03	15.2	2.4				1	1								
95.084	9.54	22.38	2.24				1	1								
96.041	9.73	18.85	2.26				1	1								
96.051	10.42	18.2	2.42				1	1								
96.064	14.47	23.91	1.31				1	1								
96.145	11.39	18.01	2.15				1	2					1	3	3	1
96.239	11.07	19.95	2.53				2	1	1	2	1	1				
97.010	10.49	20.3	1.92				1	1								
97.060	11.9		2.06	43.45	34.45	4.5	3	2					3	3	3	2
98.006	10.53	20.22	2.05				1	1								
98.065	7.98	24.88	1.53				2	1	2	3	3	1				
14.93	11.49	20.72	2.79				1	1								
87.068	8.66	18.21	2.29				1	1								
92.084	9.65	16.74	2.61				2	1	3	2	2	2				
93.065	9.05	15.51	1.77				1	1								
93.211	11.23	18.48	2.29				1	1								
95.087	10.26	17.64	2.8				1	2					3	3	3	2
95.102	9.34	18.88	1.73	40.25	33.73	3.26	2	2	2	3	3	2	2	3	3	3

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.138	10.37		1.54	43.97	34.91	4.53	3	3								
96.238	8.51	20.48	1.77				1	1								
96.245	9.19	15.34	2.07				1	2					2	3	1	1
97.150	8.58	19	1.88				1	1								
87.062	11.12	26.16	2.52				1	1								
87.145	9.91	23	2.32				1	1								
88.007	9.52	19.83	1.6				1	1								
89.039	12.1	22.81	4.21				1	1								
89.053	11.43	20.51	2.57				1	1								
89.055	11.68	20.82	2.42				1	1								
93.028	10.71		1.62	43.25	38.78	2.24	2	2	2	2	3	3	2	3	3	1
93.121	11.62	21.22	3.03				1	1								
94.061	9.61	18.09	2.23				1	1								
94.117	9.99	20.08	2.54	48.63	42.96	2.84	2	2	3	3	3	2	3	3	3	2
94.183	10.83	25.07	2.39				2	2	2	3	3	1	3	3	3	1
95.070	10.98		1.82	41.96	34.76	3.6	3	2					3	3	3	2
96.027	10.22	20.27	2.11				1	1								
96.050	12	21.45	2.64				1	1								
96.213	11.32	19.39	2.34				1	1								
97.013	12.9	19.21	2.12				1	1								
98.082	10.09	19.81	2.39				2	1	2	3		2				
87.115	8.61		1.45	45.12	40	2.56	3	3								
92.022	7.3	16.59	2.15				1	1								
94.108	11.1	18.23	2.67				1	1								
95.144	9.81	20.49	2.05				1	1								
95.156	8.64	19.21	1.78				2	2	2	3	3	2	2	2	3	3
96.018	9.02		2.02	55.16	48.32	3.42	2	3	2	3	3	3				
96.233	9.4	17.34	1.59				1	1								
98.041	10.38	16.27	2.67				1	1								
87.116	10.68	20.38	1.27				1	1								
87.156	12.65	21.37	2.37				1	1								
88.041	8.8	17.81	1.91				1	1								
88.149	10.93	19.54	2.24				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.162	9.3		2.42				3	1								
89.005	11.73	19.73	2.88				1	1								
89.066	9.2	25.41	1.68				2	2	3	3	3	2	3	3	3	2
92.099	13.02	21.1	3.2	38.85	30.62	4.12	2	1	2	2	3	1				
92.121	12.8		2.4	51.18	43.82	3.68	3	2					3	3	3	1
92.132	12.6		2.85	38.33	29.69	4.32	3	3								
92.176	11.05		1.71	42.46	36.79	2.84	3	2					3	3	3	1
93.018	8.75	22.62	2.13				1	1								
93.045	9.66	22.68	2.55				2	2	3	3	3	2	3	3	3	2
93.157	8.33	20.36	1.38				2	1	1	1	2	1				
94.010	11.16	18.33	2.11				1	1								
95.121	10.92	20.92	1.43				1	1								
97.052	8.71	22.15	2.07				1	1								
97.229	9.58	19.5	2.27				2	1	3	3	3	1				
98.039	10.98		2.36				3	3								
95.12f	9.8	17.81	3.72				1	1								
98.3f	9.68	17.01	2.33	44.16	34.55	4.81	1	2					1	1	1	1
92.101	7.63		2.17				3	2					3	3	3	1
93.002	10.32	15.62	1.84				1	1								
93.019	11		2.39	52.51	42.61	4.95	2	2	2	2	3	3	2	2	2	2
94.089	10.93	18.04	2.89	39.08	31.41	3.84	1	2					2	3	3	1
94.097	8.46	17.18	1.52				2	1	3	3	3	2				
95.136	11.57	14.45	2.33				1	1								
97.004	9.3	19.84	2.65				2	1	2	3	3	2				
97.009	10.32	19.81	2.19	39.28	31.79	3.75	2	2	2	3	3	2	3	1	1	2
97.111	9.01		1.67	42.52	34.71	3.91	3	2					3	3	3	2
98.026	10.08	20.14	2.21				1	1								
87.034	10.15	20.67	2.41				1	1								
87.081	11.27	22.92	2.51				1	2					1	3	1	3
88.013	10.53		2.44	49.11	43.09	3.01	3	3								
88.054	10	19.49	1.72				1	1								
88.112	10.31	20.22	2.25				1	1								
88.144	11.75	20.2	2.48				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
89.040	11.09		2.76	41.02	36.43	2.3	3	3								
93.163	10.13		2.16				2	3	3	3	3	2				
93.193	10.26	19.7	2.37				1	1								
93.199	13.49	23.27	1.92				1	1								
93.209	10.41	21.35	1.97				1	1								
94.126	12.13	27.83	2.37				1	1								
95.029	7.74	23.47	1.92	52.3	43.73	4.29	2	2	2	3	3	1	2	2	2	2
95.063	11.64	18.35	2.14				1	1								
96.109	12.12	23.06	2.56				1	1								
96.264	11.95		2.3	43.98	36.42	3.78	3	3								
97.095	12.1	19.95	2.37				1	1								
97.160	8.6	16.51	2.21				1	2					2	3	3	2
98.015	10.6	19.45	2.13				1	1								
98.052	11.98	19.43	1.96				2	1	2	2	3	2				
98.053	12.71	21.79	2.7				1	2					1	2	1	1
89.037	7.26	16.94	1.52	41.66	35.26	3.2	2	2	1	3	3	1	1	3	3	1
91.040	8.93	20.72	1.95				1	1								
92.026	8.31	19.29	1.9				1	2					2	3	1	1
92.133	10.65		2.44	40.77	35.63	2.57	3	3								
93.088	9.74	15.46	2.15				1	1								
93.139	8.7	19.76	1.93				2	1	1	2	1	1				
93.183	7.25	16.93	2.04				1	1								
93.187	8.1	15.55	2.35				1	1								
95.050	7.28	14.33	2.63				1	1								
95.077	10.52	24.65	1.62				1	1								
95.138	7.01		1.54				2	3	3	3	2	2				
96.080	9.07	17.41	1.74				1	1								
96.086	10.81	21.09	2.54				2	1	1	1	2	1				
96.163	9.01	17.53	1.74				1	1								
96.174	10.41	18.14	2.31	45.87	37.48	4.2	2	2	3	3	3	2	3	3	3	2
87.017	10.03	23.77	2.83				2	1	3	3	3	1				
87.090	9.31	22.55	2.2				1	1								
87.150	12.21	20.92	2.43				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
92.045	11.4	20.16	1.98				1	1								
92.046	10.47	20.9	2.06				1	1								
92.069	10.21	24.24	2.11	50.35	41.47	4.44	2	2	1	2	1	1	1	1	1	1
92.116	8.43	18.19	1.89				1	2					1	2	1	1
93.026	10.51	22.94	0.72				1	2					1	1	1	1
93.095	13.94	20.73	2.64				1	2					3	3	3	2
93.194	10	21.28	2.12				1	1								
93.228	9.37	22.65	1.3				1	1								
94.022	11.71		1.7	42.01	35.99	3.01	2	2	2	3	3	3	2	3	3	3
94.050	12.1	23.5	2.85				1	1								
95.035	8.15	19.12	2.94				1	1								
95.053	11.59	19.12	2.33				1	2					2	2	3	1
95.140	9.57		2.55	43.84	37.66	3.09	3	3								
96.002	9.13	20.18	1.31				1	1								
96.007	10.14	19.38	2.1				2	1	1	2	3	1				
96.146	12.29	22.14	1.61				1	1								
96.195	12.63	21.65	2.35				1	1								
96.202	9.49	18.39	2.08				1	1								
96.225	12.02		1.88	54.1	48.01	3.05	3	3								
97.201	12.18	20.14	2.44				1	1								
98.018	10.17	22.05	2.82				1	1								
98.035	12.18	24.03	2.59				2	1	3	2	2	2				
98.042	12.6	20.82	2.61				1	1								
3.87	8.9	22.87	1.54				2	2	2	3	3	2	2	3	3	2
2.89	9.29	23.43	3.42				1	1								
94.19f	9.84	19.79	1.92				1	1								
87.067	8.04		2.05	40.95	35.12	2.92	3	3								
88.044	11.4	18.55	2.01				1	1								
88.095	10.23		2.15	43.51	37.05	3.23	3	3								
92.081	10.06	16.41	2.18				1	1								
92.105	10.82		2.43	41.68	35.16	3.26	3	3								
93.050	8.16		1.78	43.35	35.68	3.84	3	2					2	2	3	3
94.008	7.95	19.01	1.5				1	2					3	3	3	2

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
94.013	10.96	17.63	2.28				1	1								
95.042	8.96	18.93	2.37				1	1								
95.051	7.29	15.15	1.85				1	1								
96.179	10.4	16.7	1.96				1	1								
97.164	10.23	22.76	1.5	42.92	35.83	3.55	2	2	1	1	1	1	1	3	3	1
87.114	10.57	25.04	2.56				1	1								
87.128	11.42	19.02	2.79	44.45	34.51	4.97	2	2	3	3	3	2	1	2	2	1
88.136	10.52	17.76	1.68				1	1								
92.143	12.21		2.49	49.25	42.06	3.6	3	3								
92.160	10.94	21.77	2.03				1	1								
92.166	10.75	22.61	2.53				1	1								
93.039	11.45	21.06	2.4				1	1								
93.073	9.81	20.59	1.92				1	1								
94.002	9.14	20.37	1.97				1	1								
94.052	11.42	21.49	2.15				1	1								
94.070	9.89	20.92	1.97				1	1								
94.180	9.57	20.25	2.1				1	2					3	3	2	1
95.073	10.85	22.8	2.16	49.13	41.45	3.84	2	2	3	3	2	3	3	3	2	3
95.201	10.08	17.71	2.45				1	1								
95.208	10.49	25.54	2.94	65.83	55.98	4.93	2	2	3	2	3	3	3	3	3	2
95.232	12.81	25.44	2.44				1	1								
96.025	11.26	22.68	1.97				1	1								
96.062	11.04	20.12	1.89				1	1								
96.072	8.12	14.32	1.24				1	1								
96.108	10.99		2.19				3	2					2	2	3	1
96.204	10.02	20.97	1.67				2	2	1	2	2	1	3	2	3	3
96.218	10.33	18.07	2.28				1	1								
96.258	9.95	20.95	1.7				1	1								
97.053	12.02	21.23	2.07				1	1								
97.107	11.49	18.43	2.25				1	1								
97.138	11.27		2.09				3	2					3	3	3	2
98.047	9.99	20.9	2.01				1	1								
98.071	11.01	16.29	2.66				1	1								

Specimen	***BH***	***BW***	***BT***	***GHS***	***GHD***	***MTT***	***LHF***	***RHF***	***L1***	***L2***	***L3***	***L4***	***R1***	***R2***	***R3***	***R4***
95.3f	11.03		2.31	41.46	35.67	2.9	3	3								
88.032	7.88	18.89	1.67				1	1								
88.165	8.91	19.22	2.05				2	1	1	2	2	1				
92.042	9.19	17.79	2.26	31.57	25.79	2.89	2	2	3	3	3	2	2	3	3	2
93.027	9.09	18.07	1.78				1	1								
93.052	9.35	16.07	2.01				1	1								
94.112	9.54	19.13	1.39				1	1								
94.155	8.7	19.5	1.33				1	1								
96.065	9.49	20.09	1.54				1	1								
97.021	10.29	22.7	1.39				1	2					1	3	2	1
97.181	10.96	18.94	2.34				1	1								
27.91	9.1	16.44	2.08				1	1								
88.033	14.18	19.72	2.41				2	1	2	3	3	2				
88.078	11.14	23.36	2.31	47.49	42.36	2.57	2	2	3	3	3	2	3	3	3	2
88.100	11.39	21.24	2.06				1	1								
88.127	12.46	20.68	2.19				1	1								
93.015	11.23	23.15	2.67				1	1								
93.022	10.92	20.6	2.51				1	1								
93.102	10.57	22.55	1.87				2	1	2	3	3	3				
93.133	10.4		2.85	49.44	44.87	2.29	3	3								
94.054	11.62		2.95	40.58	33.82	3.38	2	3	2	2	1	1				
94.205	11.81	20.05	1.75	45.21	36.97	4.12	2	2	2	3	3	1	3	3	3	2
95.036	10.62	21.81	2.13				2	1	2	3	3	1				
95.129	10.74	26.07	2.31				1	1								
95.160	10.61		1.92	36.23	27.96	4.14	3	2					3	3	3	2
95.165	10.55	16.25	3.24				1	2					3	2	3	2
95.169	9.62		1.46	49.35	42.08	3.64	2	3	2	3	2	3				
96.196	12.17	20.05	2.36				1	1								
96.205	8.99	21.78	2.74				1	1								
96.209	10.68	22.24	2.6				1	1								
96.229	11.08	19.63	1.16				1	1								
96.262	11.53	22.22	2.64				1	1								
97.161	9.61	21.2	1.98				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
97.186	9.94	21.75	1.82	34.19	27.86	3.17	2	2	1	1	1	1	2	3	3	2
98.007	10.56	18.18	3.23				1	1								
98.073	10.09		2.64				2	3	3	3	2	2				
5.99	9.32	22.5	2.43	44.59	37.31	3.64	2	2	2	2	3	2	1	2	3	1
88.035	10.7	22.87	2.06				1	2					3	3	3	2
92.030	10.92	18.31	2.64				1	1								
92.051	10.28	17.6	2.71				1	1								
93.217	8.27	17.69	2.12				1	1								
94.066	10.43	20.53	2.81				1	1								
95.181	7.55		1.25	45.02	38.84	3.09	3	3								
95.188	6.86	19.96	2.16				1	2					1	2	3	1
98.019	7.09	15.94	1.36				1	1								
88.140	8.93	21.04	2.21				1	1								
89.095	11.38	20.03	2.58				1	1								
92.145	11.16		2.8				1	3								
93.084	11.87	19.61	1.87				1	1								
93.141	9.57	20.82	2.41				2	1	2	3	2	2				
93.165	9.53		2.13	51.94	44.04	3.95	3	3								
93.188	11.54	20.74	1.94				1	1								
94.196	10.11	18.73	2.53	41.29	32.64	4.33	2	2	3	3	1	2	2	3	1	1
95.047	13.29	21.73	3.01				1	1								
95.054	8.86	21.06	2.51				1	1								
95.060	10.59		1.98	49.69	43.39	3.15	3	2					3	3	3	2
95.190	10.27	21.4	2.62				1	2					1	2	1	1
95.200	11.28	22.02	2.62				2	1	2	2	3	1				
97.017	11.11	20.32	2.35				1	1								
97.073	12.59		2.48				3	2					2	3	3	2
97.119	8.94		1.53				3	3								
98.093	10.51		1.5	53.56	44.65	4.46	3	3								
1.87	9.36	23.74	2.28		45		2	2	3	3	3	2	3	3	3	2
87.132	9.93	19.21	1.85				1	1								
88.040	9.89		2.11				2	1	3	3	3	2				
88.045	11.6	18.28	1.88				1	2					2	3	3	2

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.048	10.55		2.08	42.34	35.46	3.44	3	3								
89.032	8.84	16.16	1.97				1	1								
93.096	9.47	19.71	1.78	52.2	45.96	3.12	2	2	2	3	3	2	1	2	1	1
93.166	9.56	16.94	2.6				1	1								
96.019	9.36	18.3	1.54				1	1								
96.023	9.7	15.08	2.11				1	1								
96.049	9.27	16.94	1.37				1	1								
97.157	9	17.16	1.97				1	1								
97.172	8.76	17.02	2.3				2	3	3	3	3	2				
97.173	10.8	20.26	1.77				1	1								
98.10f	8.48	16.37	2.23	42.3	33.24	4.53	1	1								
87.136	11.02	20.99	3.03				2	1	3	3	3	2				
88.024	11.11	20.42	2.87				1	2					1	3	3	1
88.137	11.67	21.52	2.72				1	1								
91.102	8.55		2.33				1	3								
93.145	12.48	18.49	3.73				1	1								
93.208	11.1		2.03	48.97	39.13	4.92	2	3	3	3	2	2				
94.026	7.96		1.86	46.96	40.73	3.12	3	3								
94.096	9.36		2.6				3	3								
94.102	9.46	22.44	2.08				2	1	3	3	3	1				
96.169	9.87	20.35	1.12				1	2					3	3	3	2
96.230	11.45	18.95	2.3				1	1								
96.263	11.02		1.39	47.57	42.21	2.68	3	3								
97.005	8.93	20.41	2.14	41.32	33.81	3.76	2	2	3	3	3	2	3	3	3	2
97.059	12.15	24.08	1.61				2	2	3	3	3	2	1	1	1	1
97.067	11.08	23.33	1.99				2	2	2	3	3	2	2	3	3	1
97.098	10.01	19.89	1.9				1	1								
97.114	9.03	20.97	3.5				1	1								
97.144	12.32	20.26	2.14				1	1								
97.179	10.27	21.22	2.05				1	1								
97.224	10.16		2.33				3	1								
98.013	12.78	18.23	2.3				1	1								
98.078	12.07		3.2	46.5	39.53	3.49	2	3	2	2	3	2				

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
98.089	12.28	20.53	2.28	38.87	31.51	3.68	2	2	3	3	3	1	3	3	3	1
87.119	10.92	20.03	2.07				1	1								
88.061	7.88	17.27	1.95				1	1								
88.076	9.03	15.77	2.25				1	1								
92.085	10.61	20.51	2.14				1	1								
92.111	8.79	17.26	1.83				1	1								
97.025	9.78	17.27	2.33				1	1								
98.020	9.26	19.42	1.78	37.23	29.93	3.65	2	2	3	3	3	1	3	3	3	2
98.055	8.07		2.03				2	3	2	2	3	2				
87.077	10.08	28.65	2.65	53.28	46.98	3.15	2	3	3	3	3	2				
87.147	9.62		2.3				3	1								
88.116	9.6		1.83	47.92	39.9	4.01	3	3								
89.050	11.4	18.23	3.25				1	1								
92.117	8.2		1.85				3	3								
93.024	12.35	19.86	1.61				1	2					2	3	3	2
93.034	11.09	19.48	3.12				1	1								
93.106	13.9	25.67	2.85				1	1								
93.119	9.86	23.04	1.47				2	1	2	3	3	3				
93.190	10.86	21.29	2.6				1	1								
94.005	12.3	21.81	1.99				1	1								
94.068	9.45	17.73	1.89				1	1								
94.132	10.19	19	2.08				1	1								
94.209	9.61	18.21	2.31				1	2					3	3	3	2
95.008	11.15		2.08				1	3								
95.067	10.22	20.36	2.18				1	1								
95.072	10.84	24.15	3.88	55.66	48.4	3.63	2	1	2	3	2	2				
95.099	9.47	21.66	2.59				2	1	3	3	2	1				
95.207	10.65	20.59	1.88				1	1								
96.039	8.54	17.63	2.19				1	1								
96.161	10.19	23.69	2.04				1	1								
96.173	10.27	23.7	1.86				1	1								
97.012	13.51	22.49	2.09				2	2	3	3	3	1	2	2	3	2
97.019	11.28	25.78	2.58				2	1	2	3	3	3				

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
97.084	11.24	24.13	2.61				1	1								
97.092	13.97	22.54	1.92				1	1								
97.152	9.2	18.76	2.32				1	1								
97.216	10.89	23.43	2.22	51.49	44.22	3.64	2	2	3	3	3	2	2	3	3	2
97.228	13.09	21.88	1.97				1	1								
87.103	9.69	19.86	1.7	44.39	37.24	3.58	2	2	2	3	3	2	2	3	3	2
88.065	7.2	18.26	2.34	42.45	35.24	3.61	2	2	3	3	3	2	3	3	3	2
89.058	8.48	18.58	1.97				1	1								
92.153	8.34		1.9	42.91	34.26	4.33	3	3								
93.063	8.72		2.04	47.59	40.19	3.7	3	2					2	2	3	3
93.134	7.95	18.05	1.95				1	1								
94.046	6.24	14.39	1.28				1	1								
95.118	9.04		1.6	44.72	36	4.36	3	2					3	3	3	2
97.033	10.07	17.52	1.55				1	1								
97.123	8.49		2.01	47.18	39.33	3.93	3	3								
88.052	12.54	20.3	2.51				1	2					3	3	3	2
88.103	10.08	23.52	1.99				2	1	3	3	3	2				
88.138	10.82		3.27	50.7	40.53	5.09	3	2					2	3	3	2
89.093	13.66	17.43	2.86				2	1	3	3	3	1				
92.110	11.22	18.89	2.95	43.48	34.39	4.55	2	2	1	3	3	2	1	1	1	1
93.164	8.5	21.81	1.43				2	2	1	3	3	1	1	3	3	1
93.178	9.03		2.04				3	3								
94.131	10.92	19.85	2.09				1	1								
94.148	9.16	22.25	1.57				1	2					1	1	2	1
94.154	13.72	22.65	2.54				1	1								
94.203	10.3	21.36	2.74				1	1								
95.028	10.03	19.09	1.45				1	1								
95.105	9.87	19.48	1.37				1	1								
95.224	11.28	22.15	2.15				1	1								
96.057	11.35	22.02	1.92				2	1	2	2	2	1				
96.126	11.25	20.95	2.5				2	1	3	2	1	1				
96.166	11.54	19.89	2.94				1	1								
96.172	9.78	21.59	2.03				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.185	10.94	19.87	1.62				1	1								
97.075	14.02	20.26	1.55				2	2	1	2	2	3	1	3	3	1
97.109	11.25	22.54	3.11				2	1	3	3	3	1				
97.148	11.63		2.58	71.22	63.63	3.8	3	2					3	3	1	1
97.165	10.87		1.59				3	3								
98.016	10.1	20.08	2.55				2	1	2	3	3	2				
98.021	9.21	20.77	2.31				1	1								
98.037	11.48	21.27	1.97	49.67	42.99	3.34	2	2	2	3	3	2	3	3	3	2
00.41f	12.2	19.28	1.61				1	1								
87.118	10.81	17.7	1.3				1	2					1	3	3	1
93.083	8.54	22.38	2.52				2	2	2	3	3	2	2	3	3	3
94.134	8.93	19.42	1.8				1	1								
96.032	6.33	17.31	1.03				1	1								
96.060	8.71	18.43	1.85				1	1								
97.211	7.97	19.33	1.86				1	1								
98.024	8.49		2.02	43.18	35.38	3.9	3	3								
87.008	11.95		2.3	50.67	44.54	3.07	3	3								
87.106	8.63	20.11	1.41				1	2					1	3	3	1
87.121	12.37		2.82				3	1								
88.124	10.1	20.73	2.55				1	1								
92.134	11.53		2.26	53.45	43.86	4.8	2	2	3	3	3	1	3	3	3	1
93.001	11.34	20.24	2.36				1	1								
93.042	10.61		1.98				3	1								
93.103	11.39		1.73				1	1								
93.107	11.11	17.91	3.07				2	1	3	3	2	3				
93.115	10.89	16.3	2.39				1	1								
93.184	12.18	23.62	2.58				1	1								
94.003	10.85		1.96	48.72	43.07	2.83	3	3								
94.139	10.88		2.27				3	3								
94.156	10.84	22.4	2.17				1	1								
94.206	9.17	19.8	2.4				1	1								
95.064	9.99	20.18	1.93				1	1								
95.107	10.14	19.74	1.52				1	2					3	3	3	1

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
95.170	10.5	22.5	3.01				1	1								
95.174	9.62	20.98	1.96				1	1								
95.178	9.08	20.23	2.18	48.43	38.97	4.73	2	1	1	1	1	1				
96.033	12.23		2.23	55.42	47.78	3.82	1	3								
96.094	10.33	26.17	1.58				2	1	2	2	3	1				
96.143	10.08	19.58	2.08				1	1								
96.167	11.02	20.89	1.72				1	1								
96.227	10.69		2	44.07	37.18	3.45	3	2					3	3	3	2
97.026	10.22		2.09				3	3								
97.048	9.98	24.95	1.84	49.23	42.11	3.56	1	2					2	3	3	1
97.081	8.66	23.89	3.38	61.43	53.73	3.85	2	2	2	3	3	2	2	3	3	2
97.149	10.29	19.6	1.91				2	1	3	3	3	1				
97.196	10.42		2.21	51.74	42.09	4.83	3	2					2	3	3	2
9.89	11.54		2.16	16.48	9.8	3.34	3	3								
3.9	11.75	19.31	2.42				1	1								
88.129	9.44		1.56	40.94	34.73	3.11	3	2					3	3	3	2
94.109	9.51	13.72	2.01				1	1								
95.166	9.16	16.07	1.97				1	1								
95.197	7.71	17.52	1.3				1	2					2	2	1	1
96.036	9.92	18.9	1.35				2	1	2	2	3	3				
96.219	8.4	16.96	1.37				1	1								
97.028	10.27	17.1	1.97				1	2					1	3	2	1
96.13f	8.52	18.54	2.11				1	1								
87.111	10.02	21.92	0.97				1	3								
88.171	10.6	20.77	2.7				1	2					2	3	3	1
89.014	11.49		2.21				3	3								
92.023	9.18		2.11	45.43	36.4	4.52	2	3	3	3	3	2				
92.032	11.16		2.03	41.57	32.95	4.31	2	3	3	3	3	2				
92.033	10.45	21.1	2.58				1	1								
92.107	14.1		3.4				3	2					3	3	2	1
93.025	9.95		2.55	49.8			3	2					3	3	3	2
93.120	12.59	19.9	3.05				2	1	1	1	1	1				
93.179	9.64	22.74	1.44				2	2	3	3	3	2	3	3	3	2

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
93.218	8.99	22.94	1.54				2	2	3	3	3	2	3	3	3	2
94.048	10.68		1.93	42.3	33.17	4.57	3	3								
94.051	12.84	23.96	2.62				1	1								
94.075	9.36	23.47	2.1				1	1								
94.106	10.8	22.16	1.71				2	1	2	3	3	2				
94.12	9.29	20.32	2.15				1	2					1	2	1	1
94.171	10.65	22.96	2.4				1	1								
95.023	11.33	21.14	2.33				2	1	2	3	3	3				
96.045	10.83	17.87	2.85				1	1								
96.047	11.23	19.85	1.8				1	1								
96.068	9.48	21.24	2.17				2	2	3	3	3	2	3	2	3	2
96.122	10.01	21.81	2.06				1	1								
96.157	12.08	20.96	2.13				2	2	2	2	2	1	3	3	2	3
96.232	14.26	23.94	2.63				1	2					3	3	3	2
96.235	9.98	26.42	1.49				1	1								
96.237	11.54	20.32	2.01				1	1								
97.008	11.11	20.78	2.26				1	1								
97.031	11.34	18.29	2.39				1	1								
97.102	11.22	23.16	2.74				1	2					2	2	2	2
97.189	16.16	24.04	2.96	51.16	42.96	4.1	2	2	2	3	3	1	3	3	3	1
97.191	12.95	21.51	2.34	48.69	40	4.35	3	2					3	3	3	1
97.233	10.71	24.41	2.09				2	2	2	2	2	1	2	2	2	1
87.004p	10.26	22.52	1.94	47.07	39.58	3.75	2	2	3	3	3	2	3	3	3	2
87.033	7.68		2.15				1	3								
87.135	9.84		1.73	42.61	36.26	3.18	3	3								
88.093	9.95	17.5	1.56				1	1								
88.157	9.29	17.25	2.91				1	1								
88.173	11.52	16.41	2.04				1	1								
94.127	9.5	18.38	2.05				1	1								
97.022	9.42		2.12	40.85	33.34	3.76	2	3	3	3	2	2				
97.058	8.5	16.8	1.47				1	1								
97.126	9.1	18.1	1.96				1	1								
28.9	9.38		2.4				3	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
86.073	9.37	20.45	2.8				1	1								
87.009	13.91	22.69	3				1	1								
87.024	12.25	20.43	2.55				1	2					1	3	3	1
87.039	9.91		1.87	43.3	36.72	3.29	3	3								
87.045a	12.81		2.73	50.5	43.11	3.7	3	3								
87.091	11.23		3.04	52.9	47.8	2.55	3	3								
87.095	8.66		1.81	55.07	44.28	5.4	3	3								
87.155	10.69		2.29				3	1								
88.168	10.58	19.67	2.43				1	1								
88.170	12.13	22.21	2.82				2	1	3	3	3	1				
92.080	10.86		2.4	41.92	37.12	2.4	3	3								
92.180	9.41		2.04		42.84		3	3								
93.005	11.76	20.02	2.38				1	1								
93.108	10.22		2.17	50.38	39.81	5.29	3	3								
94.118	9.11		2.06	53.7	47.3	3.2	3	2					2	2	3	1
95.065	11.5	19.9	3.34				1	1								
95.134	11.9	23.19	1.88				2	1	3	3	3	1				
97.003	13.35	21.47	1.77				1	1								
97.038	9.78	17.91	1.67				1	1								
97.085	10.2	21.37	2.76				1	2					2	3	3	2
97.141	10.5	21.45	2.7				2	2	1	3	3	1	1	1	1	1
97.147	10.57		1.84	52.89	44.33	4.28	2	3	3	3	3	1				
97.153	11.26	23.95	2.24				2	1	3	3	3	2				
97.217	11.6		2.62	44.87	38.54	3.17	2	3	2	2	3	3				
98.063	12.29	21.52	2.17				1	1								
98.075	9.64		2.24	57.18	49.34	3.92	3	2					3	2	2	3
1.94	11.88	18.18	2.85				1	1								
88.004	9.09	19.42	1.65				1	1								
88.038	10.07	18.49	2.05				1	1								
94.016	9.48	17.05	1.7	48.36	42.18	3.09	2	2	2	3	3	2	2	3	3	3
94.039	6.47	17.27	1.63	41.28	34.69	3.3	1	2					2	3	3	1
94.091	8.32	15.91	1.55				1	1								
94.128	8.77	16.21	1.95				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
94.152	8.22	18.51	2.76				1	1								
96.042	9.13	18.57	1.8				2	1	2	3	1	1				
96.104	8.72	18.59	1.92				2	1	3	3	3	2				
96.217	7.88	17.39	1.58				1	1								
96.241	10.33	16.97	2.14				1	1								
97.062	8.75	15.96	1.7				1	1								
97.195	9.64	17.13	1.52				1	1								
88.069	10.09	18.74	1.73				1	1								
92.144		19.2					2	1	2	2	3	3				
92.158	8.77	22.44	1.58				1	1								
92.163	11.11		2.02	49.21	40.39	4.41	3	3								
92.168	13.5						2	1	3	3	3	2				
93.010	10.24	21.96	2.12				1	1								
93.064	11.88	20.82	2.99				1	1								
93.132	8.74	19.97	2.5				1	2					2	3	3	2
93.201	12.41		2.44				3	1								
93.213	12.33		2.33				3	2					3	3	3	2
93.216	9.4	19.07	2.34				2	1	2	2	3	2				
94.021	13.07	18.51	2.84				1	1								
94.092	11.51		2.02	46.65	38.02	4.32	3	2					3	3	3	2
94.146	9.4	19.9	2.1	40.69	34.84	2.93	2	2	1	1	2	1	2	3	3	2
95.075	8.92	20.87	2.42				1	2					1	2	3	1
96.005	10.37	19.08	2.25				1	1								
96.016	11.04		2.89				2	2	3	3	3	2	3	3	3	2
96.061	10.23	20.51	2.05				1	1								
96.124	9.26	20.12	1.57				1	1								
30.93	12.77		2.18				3	2					3	3	3	2
12.98	11.33	20.59	2.48	44.1	36.83	3.64	2	2	3	3	2	1	2	3	3	1
87.078	11.12	18.95	2.54	40.04	34.62	2.71	2	3	3	3	3	2				
92.020	10.11		2.24				2	3	2	2	3	3				
93.047	7.66		1.26	45.41	39.1	3.16	3	3								
95.096	8.24	18.32	2.2				1	1								
95.122	8.72	19.78	2.12				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.026	9.53		2.93	56.97	49.25	3.86	3	3								
96.168	9.34		2.16				3	2					3	3	3	2
87.028	11.85	18.88	3.11				1	2					3	3	3	2
88.028	9.87	19.62	2.01				1	1								
88.039	11.89	21.51	3				1	2					3	3	3	1
89.049	12.44	22.9	2.36				1	1								
93.044	9.93	22.63	2				2	1	1	3	3	1				
94.012	9.58		2.38	46.95	40.16	3.4	3	3								
94.014	8.93	19.8	1.91				1	1								
94.119	13.68		3.72				3	3								
95.175	8.9		2.22	64.39	54.66	4.87	3	3								
95.186	9.95	20.63	2.21	44.39	35.73	4.33	2	2	3	3	3	2	3	3	3	2
95.193	9.72	19.26	1.28				2	2	2	3	3	1	3	3	3	2
96.012	10.1	22.3	2.21	49.58	43.72	2.93	2	2	2	3	3	3	2	3	3	2
96.081	9.25	23.28	1.68				1	1								
96.220	11.66	20.64	2.04				1	1								
96.253	10.33	22.44	1.52				1	1								
97.063	11.31	23.15	2.55				1	1								
97.113	11.03		1.63	40.67	30.51	5.08	3	3								
97.137	13.32	25.71	2.22				1	1								
97.143	11.34	22.61	2.12				2	2	3	3	2	1	3	3	3	1
98.094	9.02	23.8	2.96				2	1	1	3	3	1				
12.88	10.72	22.66	2.64	40.82	34.41	3.21	2	2	3	3	3	2	3	3	3	2
01.100a	10.58		2.05				3	3								
88.021	8.91	17.71	1.88	38.9	30.83	4.04	2	2	3	3	3	1	2	3	3	2
88.121	10.31	19.73	1.85				1	1								
92.043	9.96	18.25	2.34				1	1								
94.190	8.52	18.46	1.49				1	1								
95.031	8.69	17.48	1.85				2	1	2	3	2	2				
95.083	7.42	17.93	2.45	45.25	37.54	3.86	2	2	3	3	3	2	2	3	2	2
97.230	8.86	18.51	2.07				1	2					2	2	3	3
87.007	10.94		2.93	49.88	42.86	3.51	3	3								
87.130	9.73	18.85	2.15	47.8	38.63	4.59	2	2	2	2	2	2	2	2	2	2

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.055	9.7	24.07	2.49				2	2	3	3	3	1	3	3	3	1
88.126	10.13		2.27				1	3								
89.098	9.27		2.98	43.49	36.01	3.74	2	2	2	2	3	3	2	2	3	3
92.147	10.24		2.3	47.11	42.09	2.51	3	3								
92.174	11.67		2.81	47.73	37.82	4.96	3	3								
93.062	11.15	19.19	3.29				1	1								
93.152	10.44		1.91				2	3	3	3	3	1				
94.032	9.63	20.41	1.93				1	1								
94.041	11.93		2.28	50.03	43.18	3.43	3	3								
95.110	10.03	20.65	1.21				1	1								
95.119	9.89	18.74	2.15				2	1	2	2	2	1				
95.124	9.19		1.95				3	3								
95.153	11.45	19.91	1.39				1	1								
95.204	11.22		1.91	44.95	39.41	2.77	2	2	3	3	3	2	2	3	3	3
95.226	12.98	21.21	2.23				1	1								
96.088	12.06		1.84	45.77	36.41	4.68	3	2					3	3	3	2
96.128	12.23		1.78				3	3								
96.199	10.62	22.6	1.95	42.49	36.62	2.94	2	2	2	3	3	2	2	3	3	1
96.228	9.56	20.08	2.31				2	1	2	2	3	2				
97.002	11.36	20.31	1.73	53.06	46.64	3.21	2	2	2	3	3	2	1	2	2	1
97.042	11.91	22.54	2.45				2	2	2	3	3	2	2	3	3	2
97.133	12.04		1.9	50.98	43.36	3.81	3	3								
97.174	12.96	19.06	2.32				1	1								
97.226	9.94		2.15	42.26	36.71	2.78	3	2					3	3	3	2
87.019	9.29		1.88	45.51	38.03	3.74	2	3	3	3	3	1				
88.060	8.81	16.35	2.05	45.58	38.33	3.63	2	2	3	3	3	2	1	3	1	1
88.064	8.51	19.39	2.57				1	1								
89.004	9.99	19.32	2.44				2	1	3	3	3	2				
93.008	8.6	16.04	2.3				1	1								
93.137	9.13	18.2	1.87				2	1	1	2	1	1				
94.201	8.04		1.72				3	2					2	2	3	1
96.082	9.8	17.35	1.44				1	1								
96.084	8.24	18.79	1.99				2	1	1	3	2	1				

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
97.001	8.44	19.71	1.58				2	2	2	3	3	1	2	3	2	2
97.068	9.43	15.96	2.21				1	1								
97.223	7.23		1.78	41.14	33.72	3.71	3	2					2	3	3	2
87.089	10.22	22.14	1.73				1	1								
87.126	11.14	22.78	2.35	46.48	36.86	4.81	3	2					3	3	3	1
87.129	11.57	19.01	2.29				1	1								
88.003	11.14	19.73	1.88				1	1								
88.019	10.2		2.13	44.56	36.76	3.9	3	3								
88.117	9.43		1.8				3	1								
88.130	8.07		2.19				3	2					3	3	3	2
89.036	10.38	22.59	1.79				1	1								
92.074	12.39	20.16	2.78				1	1								
92.076	12.29	22.22	3.32	42.15	34.1	4.03	2	2	3	3	3	2	3	3	3	2
93.136	9.98		2.95	51.56	44.09	3.74	3	3								
94.177	12.78	20.64	2.56	43.51	36.2	3.66	2	2	3	3	2	2	2	2	1	3
94.186	10.44	25.73	2.8				1	2					2	3	3	1
95.037	10.76		2.67	47.6	41	3.3	3	3								
95.113	11.36	21.58	2.17				1	1								
95.164	9.39	19.44	2.89				1	1								
96.107	10.81		2.15	47.59	41.82	2.89	2	3	3	3	3	1				
96.226	11.53	21.95	1.27				1	1								
96.243	13.15	22.8	1.93				1	1								
97.015	9.33		2.63	41.03	34.66	3.19	2	1	3	3	3	2				
97.027	13.85	21.09	1.54				1	1								
97.064	12.09	24.27	1.59				2	2	2	2	3	2	2	3	2	2
97.204	10.49	20.5	2.39				1	1								
98.043	10.53		2.06				3	3								
98.085	10.77	23.79	2.66	46.8	35.63	5.59	2	2	3	3	3	1	3	3	3	1
98.088	12.13		2.21	44.66	38.53	3.07	3	2					3	3	3	2
10.88	12.29		2.77	47.24	39.97	3.64	3	3								
96.19f	12.38		2.49	43.01	37.22	2.9	2	3	3	3	3	2				
88.128	9.85		2.59				2	3	3	3	3	2				
93.191	9.17	16.41	1.61				1	1								

Specimen	BH	BW	BT	GHS	GHD	MTT	LHF	RHF	L1	L2	L3	L4	R1	R2	R3	R4
96.141	9.4	16.88	2.12				1	1								
86.094	10.64	21.57	2.32				1	1								
87.020	12.03	20.31	2.36				1	1								
88.009a	10.53	19.7	1.75				2	1	1	3	2	1				
88.056	11.52	21.62	2.85				1	2					2	3	3	3
88.066	11.26		2.89	44.76	37.61	3.58	3	3								
93.023	11.87		2.1				3	1								
93.085	10.52		2.89	37.38	29.55	3.92	2	3	2	3	3	2				
94.060	10.64	24.02	1.21				1	1								
94.199	11.49	20.26	3.09				2	1	3	3	3	1				
95.030	8.89		1.56	40.67	33.91	3.38	2	3	3	3	3	1				
95.069	10.14	24.08	2.74	38.24	30.96	3.64	2	2	3	3	3	1	3	3	3	1
95.139	10.99	22.08	2.22				1	1								
95.187	11	22.83	2				2	1	2	2	3	1				
96.184	12.19	22.03	3.38	47.96	40.18	3.89	2	2	3	3	3	2	1	2	2	1
96.214	10.18	23.47	2.27	45.58	37.75	3.92	1	1								
96.223	9.02		1.79	52.71	44.23	4.24	3	3								
97.039	12.17	23.64	1.9				1	1								
97.151	9.98	21.52	2.44				1	1								
97.182	11.77	24.05	2.19				1	1								
97.236	8.58	18.28	1.6				1	1								
98.077	10.18	21.64	2.28	47.6	38.88	4.36	2	2	2	3	2	2	2	2	2	2
01.134a	10.4		0.92				3	1								
93.198	7.64	18.16	1.71				1	2					1	3	3	1
93.204	9.07		1.54	44.96	36.48	4.24	3	3								
94.065	7.55	19.04	1.86	46.52	40.66	2.93	2	2	2	3	3	3	2	3	3	2
96.181	10.88	19.01	2.06				1	2					3	3	3	1
97.103	9.13	19.41	1.51				1	2					3	3	3	2
23.88	9.53	18.01	2.49				2	1	2	3	3	2				
87.025	11.02	21.98	2.35				2	1	3	3	3	1				
88.094	8.85		1.68				3	2					3	3	3	1
88.148	9.78		2.39	53.61	45.59	4.01	3	3								
88.164	10.88	21.69	1.87	39.09	34.2	2.45	2	2	3	3	3	1	1	3	1	1

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
89.034	11.36		2.57	49.03	38.48	5.28	3	3								
92.083	12.29	21.88		41.37	32.66	4.36	2	2	2	2	2	2	2	2	2	2
92.126	11.2		3.04	46.48	41	2.74	3	3								
93.093	10.18	17.27	3.29				1	1								
93.156	12.54	25.93	2.42				1	1								
93.202	12.39	22.96	1.91				1	1								
94.099	11.64		3	44.42	35.22	4.6	2	3	3	3	3	1				
94.143	11.8	21.93	1.51				1	1								
95.079	10.4	20.27	2.07				1	1								
95.092	9.43	19.4	3.25				1	1								
95.216	9.93	20.92	1.8				1	1								
96.017	10.61		2.12				3	3								
96.052	11.55	20.3	2.31				1	1								
97.018	12.35	25.19	2.39	47.2	36.91	5.15	2	2	2	3	3	2	2	3	3	2
97.029	9.58		1.7	41.72	33.36	4.18	2	3	2	3	3	2				
97.035	10.82	24.18	3.15				2	1	2	2	3	2				
97.170	10.99	22.42	3.17				1	2					2	3	3	1
97.171	11.32	19.94	3.37				1	1								
97.178	9.88	19.02	2.29	49.25	41.58	3.84	1	2					1	2	2	1
97.203	10.76	21.04	2.4				2	2	3	3	3	2	2	2	3	2
98.040	11.67	21.04	2.29	44.64	38.58	3.03	3	2					2	2	3	1
98.090	11.61	19.44	2.38				1	2					2	3	3	1
4.89	10.01	17.13	2.4	34.48	27.81	3.34	2	2	3	3	3	2	2	3	3	2
88.145	9.21	16.52	1.17				1	1								
89.028	10.42	19.21	2.25				1	1								
95.120	8.53	16.8	2.27				1	1								
95.173	8.88	14.77	2.02				1	1								
96.123	9.48		1.55				3	2					3	3	3	2
97.183	10.4	18.23	1.83				1	1								
98.062	8.22	17.05	1.91				1	1								
99.29f	9.49	17.79	2.87				1	1								
87.011a	11.38		2.28				3	2					3	3	3	1
87.012	10.46		2.88				3	1								

Specimen	***BH***	***BW***	***BT***	***GHS***	***GHD***	***MTT***	***LHF***	***RHF***	***L1***	***L2***	***L3***	***L4***	***R1***	***R2***	***R3***	***R4***
87.093	12.32	24.01	2.66	31.93	26.21	2.86	2	2	2	3	3	1	1	3	3	1
87.113	13.14			50.07	44.13	2.97	3	3								
88.104	10.56	19:5	3.49	35.92	29.72	3.1	1	2					1	3	3	1
93.014	11.55	24.11	2.26				1	1								
93.210	10.06	23.05	2.14				1	1								
94.025	10.46		3.03				3	2					1	3	3	1
94.142	10.12	21.14	1.95	43.95	37.45	3.25	2	2	2	3	3	2	1	1	2	1
94.158	11.11	18.86	2.5				1	1								
95.048	8.02		1.95	46.98	38.54	4.22	3	2					1	2	2	1
95.061	10.5	23.33	2.5				1	1								
96.127	9.23	18.36	2.37				2	1	2	2	3	3				
96.265	13.21		1.88	46.54	41.28	2.63	3	3								
97.112	11.1	19.09	1.83				1	1								
97.210	12.96	18.42	2.57				1	1								
98.023	12.81		2.47	49.94	45.26	2.34	3	2					1	2	2	1
98.031	9.67	19.68	2.18	45.11	35.96	4.58	2	2	2	2	3	2	2	2	1	1
98.054	10.66	19.01	2.64	42.64	33.9	4.37	2	2	2	2	2	2	2	3	2	2
98.070	9.32	23.79	2.05	51.07	44.05	3.51	2	2	2	3	2	1	2	3	2	2
12.9	11.74	21.9	2.82				2	1	2	3	3	1				
88.120	10.77	17.44	2.28	41.34	32.07	4.64	2	2	3	3	3	2	2	3	3	2
89.101	9.08		2.08	42.14	37.27	2.44	3	3								
92.089	11.49		1.95				2	1	3	3	3	1				
93.149	9.65	14.22	2.01				1	1								
98.029	8.14	18.8	1.86				1	1								
87.066	11.54	24.85	2.07				1	1								
87.154	12.28		2.34	50.42	41.67	4.38	3	3								
88.006	9.26	21.28	2.89				2	1	2	3	3	3				
92.156	12.31		2.2	45.87	39.26	3.31	2	3	3	3	2	2				
94.173	11.6	22.18	2.43				1	1								
94.197	11.12		2.6	42.79	39.64	1.58	2	3	3	3	3	2				
95.199	11.32		2.01	49.26	41.99	3.64	2	3	2	3	3	2				
96.010	9.23		2.32	38.42	30.31	4.06	2	3	3	3	3	1				
96.090	11.41	21.74	2.23	45.93	39.23	3.35	2	2	3	3	3	2	3	2	2	2

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.155	11.98	22.97	1.95				1	1								
96.240	9.93		1.71				3	1								
97.050	12.33	21.28	2.57				1	1								
97.065	10.91	20.1	2.11				1	1								
97.108	9.44	24.02	1.57	47.63	37.65	4.99	2	2	3	3	3	2	2	3	3	2
97.110	10.76	20.44	2.79				1	2					3	3	3	2
97.129	9.4	20.6	1.83				1	1								
11.89	9.31	23.69	2				2	1	2	2	3	2				
5.93	8.55	21.12	2.25				2	2	3	3	3	2	3	3	3	2
94.22f	10.65	20.7	2.34				2	1	2	3	3	1				
00.20f	11.86	21.4	1.37				2	1	1	2	3	1				
96.037	9.46	15.17	1.54				1	1								
97.128	9.27	18.02	2.17				1	1								
87.020a	9.89	19.39	2.41				1	1								
87.029a	11.67	21.21	2.31				1	1								
87.040	9.06	21.74	1.75				1	2					3	3	2	3
87.064	10.69		2.23				1	3								
88.001	10.71		1.74	48.67	42.19	3.24	3	3								
88.139	11.19	23.41	1.58				1	1								
89.102	12.05	21.96	2.06				1	1								
92.039	9.34		2.37	44.45	36.27	4.09	3	3								
92.049	10.81		2.96				1	3								
92.094	9.64		2.01	36.65	29.01	3.82	3	2					1	3	3	3
92.097	10.79	19.67	2.77				1	1								
93.117	10.36	21.06	2.11	43.65	35.11	4.27	2	2	2	3	3	3	2	3	3	1
93.180	10.64	22.39	1.72		34.3		2	2	3	3	3	1	1	1	2	1
93.186	10.16	24.6	1.94				1	1								
94.017	8.66		1.79	48.81	41.16	3.83	3	3								
94.080	12.29		3.57	45.09	38.81	3.14	3	3								
94.090	11.24	22.68	1.6				2	1	3	3	3	1				
94.098	11.6	20.43	2.5				1	1								
94.114	8.11	18.71	1.86				1	1								
95.020	10.2	21.68	2.43				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
95.049	11.39	21.44	2.2				1	1								
95.055	11.15		1.66	49.52	42.32	3.6	3	2					3	3	3	1
95.215	9.44	22.65	3.11				1	2					1	2	3	2
96.043	11.12		2.19				1	3								
96.194	11.4	18.76	2.21				1	1								
97.071	8.4	22.17	2.11				1	1								
97.091	10.2	24.13	1.35				1	1								
97.097	11.59	22.71	2.55				1	1								
97.214	12.17	22.53	2.3				1	1								
97.235	12	23.08	2.47				1	1								
98.079	9.9	18.99	1.37				2	1	1	3	2	2				
27.9	11.29		2.44				3	2					2	2	3	2
87.076	10.25	17.54	1.77				1	1								
87.098	9.78		1.7	46.87	39.51	3.68	3	3								
88.042	11.08	17.02	1.9				1	1								
88.119	9.06		2.27	34.21	28.85	2.68	3	3								
89.074	10.96	16.1	3.65				1	1								
94.084	10.68		1.96				2	2	3	3	2	2	3	3	2	2
96.029	8.34		1.78				2	3	3	3	3	2				
96.054	9.9	17.47	2.68				1	1								
97.188	11.28	18.56	2.59	34.45	27.32	3.57	2	2	3	3	3	1	3	3	3	1
87.071	10.27	21.35	2.57				1	1								
87.105	10.34	20.81	2.28				2	1	2	3	3	1				
87.133	10.43		2.36	42.25	36.4	2.93	3	3								
89.064	11.55	22.51	2.09				1	1								
92.140	10.59	20.93	2.43	47.39	41.31	3.04	2	2	2	3	2	2	2	2	2	2
92.146	9.17	18.69	2.52				1	1								
93.060	10.99		1.9	44.74	35.34	4.7	3	3								
93.094	10.44		1.28	48.32	39.35	4.49	3	2					1	3	3	1
93.125	11.55	18.83	2.56				2	1	3	3	2	2				
94.053	12.55	21.96	2.42				1	1								
95.027	9.93		2.19	38.57	30.7	3.94	2	3	3	3	3	2				
95.202	9.78	17.96	1.99				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.053	12.02		2.18	52.13	43.99	4.07	3	3								
96.151	11.09	22.33	2.21				1	1								
97.047	12.11	23.99	2.16				1	2					3	3	1	1
98.074	12.22	20.09	2.93				1	1								
1.82	10.11	25.39	2.92	51.37	45.94	2.72	2	2	3	3	3	2	3	3	3	2
4.87	10.32		2.88	42.02	34.29	3.87	3	2					2	1	3	2
1.92	11.57		2.49				3	3								
36.93	9.46	23.05	2.01				2	1	3	3	3	2				
39.93	11.22	23.54	2.23				1	1								
4.96	10.1		2.57	49.61	42.91	3.35	3	3								
87.142	10.01		2.34	46.64	39.81	3.42	3	3								
88.082	7.63	17.01	1.67				1	1								
93.013	8.02	16.77	1.92				1	1								
93.130	7.61		1.55				3	3								
94.063	9.04	14.93	1.93				1	1								
95.025	10.73	19.06	2.24				1	2					2	2	3	2
87.041	9.11	18.35	3.1				1	1								
87.047	11.11	21.47	2.3				1	1								
87.083	11.32	19.27	1.64				1	1								
88.085	12.89	24.05	2.44	61.51	53.77	3.87	2	2	3	3	3	2	3	3	3	1
88.109	9.22	26.3	1.42				1	1								
89.052	12.6	21.8	3.29				2	1	3	3	3	2				
92.154	9.13	19.95	1.69				1	1								
93.011	8.88		2.09				3	3								
93.029	9.36	24.32	2.38				2	2	3	3	3	1	3	3	3	2
93.082	11.36	22	2.64				2	1	3	3	3	1				
93.197	10.9		2.36	43.24	36.19	3.53	3	3								
95.046	11.33	24.99	1.91				1	1								
95.128	10.03	22.35	2.1				1	2					3	3	2	3
95.211	12.84	20.64	2.69				1	2					1	3	2	1
96.022	11.79	22.22	1.14				1	1								
96.071	10.94	20.18	2.44				2	1	2	3	3	1				
96.112	10.44		1.96	47.87	41.71	3.08	3	3								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.118	12.42		2.91	45.17	35.41	4.88	3	3								
96.120	10.72	20.61	2.01				1	1								
96.183	10.12		2.62	55.73	48.73	3.5	2	1	3	3	3	2				
96.203	10	25.87	2.87				1	1								
96.206	10.45		2.32	44.37	38.01	3.18	3	3								
96.242	10.57	22.61	2.25				1	1								
97.032	12.8	21.9	1.76	45.15	36.67	4.24	1	1								
97.154	8.66	24.21	2.16	49.44	42	3.72	2	2	2	3	3	2	3	3	3	1
97.197	10.03		2.9	48.1	40.94	3.58	3	3								
98.051	10.11	22.94	2.3	49.41	40.39	4.51	2	2	3	3	3	2	3	3	3	1
14.88	13.37	23.57	3.04				1	1								
10.95	12.57	19.91	1.84				1	1								
88.047	8.78	20.63	2.35				1	1								
89.072	8.04		1.99	52.41	44.62	3.9	3	2					3	2	3	3
94.138	7.37	16.99	1.37				2	1	2	2	2	2				
95.184	9.8	19.71	1.78	46.58	35.98	5.3	2	2	2	2	2	1	1	2	2	1
87.016a	10.77	23.47	2.52				1	1								
87.040a	11.76	24.02	2.17				1	2					3	3	3	1
87.062b	11.7		2.27	44.46	37.68	3.39	2	3	3	3	3	1				
92.127	11.36		3.04				1	2					3	3	2	2
93.077	10.22	24.97	2.37				1	1								
94.107	10.3	23.35	2.6				1	1								
94.178	9.86	22.45	1.87				2	1	3	3	3	2				
95.159	7.72		2.2	45.43	38.63	3.4	3	3								
95.185	10.53		2.25	46.24	38.04	4.1	3	3								
96.113	9.93	21.58	2.17				1	1								
96.165	12.46	19.23	2.31				1	1								
97.083	11.42	20.02	2.56	36.89	30.88	3.01	2	2	3	3	2	3	2	3	3	3
97.100	10.76		2.79	65.96	57.04	4.46	3	2					2	3	3	2
4.99	10.88	24.31	3.1				2	1	2	3	3	1				
95.227	9.31	16.99	2.22				1	1								
97.180	8.88	19.47	2.03	42.38	34.57	3.91	2	2	1	2	2	1	3	3	1	1
98.030	9.02	18.82	1.84				1	2					1	3	3	1

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.002	10.01		2.14				1	3								
88.125	11.78		2.6	48.38	39.87	4.26	3	3								
89.001	10.34	19.32	2.91				1	2					2	2	2	1
89.027	9.81	18.37	2.52				1	1								
92.050	11.73		1.92	34.99	28.81	3.09	3	3								
94.055	8.91	17.67	2.47				2	2	3	3	3	2	3	3	3	2
95.088	10.65		1.28	46.68	37.63	4.53	3	2					3	3	3	2
96.044	10.94		1.14	43.87	37.08	3.4	3	3								
97.140	9.23		2.12	51.09	44.17	3.46	3	2					2	3	3	3
98.033	10.19	23.65	1.59				1	1								
98.080	9.6	21.48	2.09	48.22	40.64	3.79	2	2	3	3	3	2	3	3	3	2
7.87	7.58	17.78	2.69	33.73	27.73	3	2	2	2	3	3	2	3	3	2	3
18.91	8.94	26.98	3.1	58.25	50.44	3.91	2	2	2	3	3	2	2	3	3	2
87.043	9.62	19.69	1.52				1	1								
89.025	10.97	18.1	2.51				1	1								
95.161	7.77		2.31	46.55	38.51	4.02	3	2					3	3	3	2
96.008	8.01	16.71	1.69	39.47	32.64	3.42	2	2	3	3	3	2	3	3	3	2
96.177	9.7		2.31	38.39	30.99	3.7	3	2					3	3	3	1
96.252	9.55	20.44	1.88				2	1	3	3	3	2				
97.006	9.45	20.13	1.86				1	1								
97.142	7.13	18.95	1.05				2	1	3	3	3	2				
97.146	9.78	18.14	1.44				1	1								
86.091	10.55	18.34	2.56				1	1								
87.012a	11.05	22.18	4.44				2	1	3	3	3	2				
87.074	11.92	21.35	2.65				1	1								
87.094	11.21	22.26	2.16				1	1								
87.124	12.81		2.2	34.68	27.89	3.4	3	3								
88.083	11.23		2.22	38.53	32.98	2.78	3	3								
89.029	12.82		2.86	40.12	32.62	3.75	3	3								
89.076	11.64	21.58	1.81	51.21	43.79	3.71	2	2	2	3	3	1	3	3	3	1
93.035	9.28	19.81	2.65				1	1								
93.203	11.63		1.85				3	3								
94.004	11.9	25.51	2.43				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
94.028	11.09	19.09	1.62				1	1								
94.031	10.92		2.64				1	1								
96.149	11.78	20.91	3				2	2	3	3	2	3	1	2	2	1
96.164	11.24		2.02				3	3								
97.054	12.5	19.74	2.6				1	1								
97.061	10.98	17.26	2.57				1	1								
97.089	9.93	21.27	2.44	53.48	45.24	4.12	2	2	3	3	3	1	3	3	3	1
97.099	12.74	23.3	2.87				2	2	3	3	3	1	3	3	3	1
97.212	11.14	20.71	2.6				2	1	2	3	3	2				
01.37f	12.29		2.1				3	3								
87.001p	9.15	19.79	2.02				1	1								
93.185	8.6	18.2	1.79				2	1	3	3	3	1				
95.146	10.09	17.73	2.06	48.03	39.71	4.16	2	2	1	2	2	1	1	2	2	1
95.182	10.21	15.67	1.81				1	1								
96.009	8.86	18.79	2.52	38.51	31.4	3.56	2	2	1	3	3	1	2	3	3	1
98.044	7.35	17.23	1.59				1	1								
87.003a	12.59	22.48	2.95	58.39	51.2	3.6	2	2	3	3	3	2	1	1	2	1
87.003p	13.36		2.08	60.12	52.8	3.66	3	3								
89.084	11.21	19.2	3.17				2	2	3	3	3	2	2	3	3	3
92.082	10.87	23.7	2.68				1	1								
92.170	9.8		2.37				2	3	3	3	3	2				
93.135	8.94	19	2.25				1	1								
95.093	11.3	24.38	3.15				1	1								
95.220	9.2		2.07				3	3								
96.089	12.4	20.26	2.28				1	1								
96.153	8.47	16.37	2.73				1	1								
96.182	11.71		2.55				2	3	2	3	2	1				
01.15f	11.39	20.5	2.13				1	1								
87.060b	9.87	24.71	2.32				1	1								
88.115	7.93	16.59	2.15				1	1								
88.153	7.92	18.82	1.9				1	1								
94.088	9.4	20	2.53				2	2	3	3	3	2	2	3	3	2
96.137	8.71	15.94	1.73				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.256	9.82	19.58	2.37				1	1								
87.005a	10.84	24.98	2.26	44.16	38.19	2.99	2	3	3	3	3	1				
87.051a	9.82	22.15	2.48				1	1								
88.091	11.65	24.95	2.16	47.28	39.48	3.9	2	2	3	3	3	1	3	3	3	1
89.054	11.36	21.96	2.63				1	1								
92.034	10.08	17.89	2.19				1	1								
92.047	9.77	22.6	2.14				1	2					1	1	2	1
92.167	10.07		2.62				3	1								
92.173	12.6		2.58				3	3								
93.124	12.78	22.38	2.23				1	1								
93.181	8.67		2.97				3	3								
94.049	12.87	21.19	2.03	49.13	40.77	4.18	2	2	3	3	3	2	3	3	3	2
95.101	11.62	18.54	1.6				1	2					1	2	1	1
95.194	11.21		1.41	48.45	36.8	5.83	2	3	3	3	3	2				
96.014	12.21	23.13	2.04	54.3	47.5	3.4	2	2	2	3	3	2	3	3	3	1
96.077	9.72	20.14	2.18				1	1								
98.010	9.73	21.71	1.38				1	1								
29.99	11.88		1.91				3	1								
96.078	7.84		2.07	44.16	36.05	4.06	3	3								
96.106	9.17		1.89				3	3								
96.178	8.06		2.46	35.62	30.26	2.68	3	2					3	3	3	2
6.92	8.53	18.57	1.89	48.47	40.87	3.8	2	2	3	3	3	2	3	3	3	2
86.087	10.71	19.18	2.63				2	1	1	3	3	1				
87.058	10.22		2.69	55.49	48.1	3.7	3	3								
87.060A	10.69	20.16	2.22				1	2					1	3	2	2
87.072	9.64	20.37	2.44				2	2	3	3	3	2	3	3	3	2
88.059	11.21	20.62	1.84				1	1								
89.031	11.95	20.44	3				1	1								
95.167	11.04	19.84	2.85				2	2	3	3	3	2	3	3	3	1
96.013	11.75	23.09	2.82				1	1								
97.190	10.86	21.22	2.07				1	1								
3.83	10.63	20.67	2.51				1	2					2	2	2	3
20.95	10.93		2.96				1	3								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
2.99	11.46	22.51	2.92				1	2					3	3	3	2
92.092	9.01	22.96	1.7	46.18	39.68	3.25	2	2	3	3	3	2	3	3	3	2
86.085	10.76	21.86	2.18				2	1	2	2	3	2				
87.001a	10.24	24.01	2.47				2	2	3	3	3	1	3	3	3	1
87.014	9.82	24.08	3.21				1	2					2	3	3	3
87.034a	10.52		3	47.17	38.73	4.22	3	2					3	3	3	2
87.041a	11.1		1.87	59.35	48.84	5.26	3	2					3	3	3	2
87.057a	11.49		2.24	41.79	36.1	2.85	3	3								
87.159	10.44	22.72	3.06	45.67	38.87	3.4	2	2	3	3	3	1	3	3	3	1
88.063	10.47	21.98	2.41				1	1								
89.086	10.67	20.93	1.94	52.48	47.21	2.64	2	2	3	3	3	2	3	3	3	2
92.086	13.68		2.07	46.64	40.1	3.27	3	3								
93.021	11.3	23.04	2.65	46.13	38.05	4.04	2	2	1	3	3	1	1	3	3	1
94.007	10.53		1.72				3	3								
94.034	9.55	20.39	1.82				1	1								
94.073	11.03	25.65	1.85				1	1								
94.100	13.42	22.7	2.13				2	1	3	3	3	2				
95.214	10.84		2.17	48.83	41.59	3.62	3	3								
96.119	13.27		1.95	48.18	42.31	2.94	3	3								
96.140	11.3	17.52	1.4				1	1								
97.016	11.33	24.34	2.94	50.35	38.74	5.81	2	2	3	2	1	3	2	3	3	2
97.169	9.91	19.17	1.82				1	1								
98.034	10.83	19.15	2.85				1	1								
11.94	9.1	21.22	2.12				1	1								
87.140	10.03	19.2	1.2				2	2	1	3	3	2	1	3	3	1
93.122	9.31	17.65	1.68				1	1								
95.209	8.51	18.41	1.72				1	1								
95.230	10.46	17.31	1.9				1	1								
97.106	9.35	17.63	1.67				1	2					3	3	3	1
86.079a	10.11		1.75				3	2					2	3	3	3
87.019a	11.9		2.91	50.37	40.65	4.86	3	3								
87.032a	10.28		2.41				1	3								
88.169	10.72	26.62	2.74				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
89.051	10.08	20.75	1.6				1	1								
93.009	10.69	18.81	2.78				1	1								
93.214	11.3	21.9	1.87				1	1								
95.056	11.59	19.82	2.2				1	1								
95.191	11.88	17.74	2.64				2	2	2	3	3	2	3	3	3	2
97.127	12.18		2.74				3	3								
97.175	12.01		2.03				3	3								
87.110	8.92	17.99	2.09				1	2					3	3	3	1
88.163	7.61	19.12	1.87				2	1	3	3	3	1				
89.045	9.1	16.12	1.3				1	1								
92.138	9.61		1.46				3	2					2	2	2	3
86.074a	10.62	24.27	2.46	53.14	44.57	4.29	2	3	2	2	3	2				
87.018a	14		3.19				3	1								
87.030	9.46	17.32	2.65				1	1								
87.039b	10.71	23.09	2.01				1	1								
88.152	12.52	18.88	3.56				1	2					2	3	3	1
89.003	9.55		2.17	44.91	39.01	2.95	3	3								
92.019	8.48	20.71	2.21				2	2	3	3	2	2	3	3	3	2
92.036	11.63		3.03	51.09	43.7	3.7	3	3								
93.089	11.94		3.04				3	1								
93.098	10.38		2.36				3	3								
93.206	9.6		2.86	50.02	41.13	4.45	3	3								
94.043	9.63	20.58	1.61				1	1								
95.130	11.84		1.58				3	3								
96.087	11.1	23.49	2.58	47.15	38.91	4.12	2	2	3	2	2	1	2	3	3	2
96.111	8.07	20.41	2.4				1	2					1	1	1	1
96.231	11.77		2.14	45.87	39.42	3.23	3	3								
96.255	10.5	20.9	1.88				1	1								
97.094	12.18		2.03				2	3	3	3	3	1				
97.124	12.32	21.41	3.34				1	1								
97.206	10.89	20.96	1.7	52.66	44.15	4.26	2	2	3	3	3	2	1	1	1	1
98.092	11.46	22.36	2.17				2	2	3	3	3	1	1	1	1	1
6.91	11.17	24.04	2.86	51.97	44.23	3.87	2	2	3	3	3	1	3	3	3	1

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.085	10.64	17.77	2.07				2	2	1	1	1	1	1	1	1	1
97.163	9.78	14.88	1.83				1	1								
1.96	8.78	18.78	1.65				2	2	3	3	3	2	2	3	3	2
3.99	9.16		2.11				3	3								
87.043a	10.07	24.28	2.3				1	1								
87.044a	10.12		2.31				2	3	3	3	3	2				
92.072	10.91		3.04	67.41	56.92	5.25	2	3	2	3	3	2				
93.076	11.14		3.11				3	3								
93.081	11.28		3.55	53.24	45.22	4.01	3	3								
93.101	10.08	18.87	2.22				1	1								
95.176	10.82	22.38	2.48				1	2					2	2	2	1
95.222	10.56		1.52	44.69	37.38	3.66	3	3								
97.043	9.95	21.99	2.64				2	2	2	3	3	2	2	3	3	2
97.090	10.97	18.64	1.74				1	1								
88.002a	10.81		2.63				3	1								
88.075	9.4	22.61	1.8				1	2					1	3	3	1
88.077	9.97	22.14	2.04				2	1	2	3	3	2				
94.018	9.14	15.16	1.73	35.56	30.52	2.52	2	2	2	3	3	2	2	3	3	2
94.124	8.43		1.83				3	3								
87.070	11.32	22.12	2.54	47.75	39.66	4.05	2	2	3	3	3	2	3	3	3	1
87.108	8.73	23.13	1.89	51.2	43.64	3.78	3	3								
88.027	10.15		2.66	47.26	37.99	4.64	2	3	3	3	3	2				
88.043	12.09	20.38	2.41				2	1	3	3	3	2				
89.056	13.2	22.74	3.05	43.93	36.76	3.59	2	2	2	3	3	3	3	3	3	2
92.055	10.45	20.87	2.61				1	1								
92.075	8.82		2.35	52.71	46.59	3.06	2	3	3	3	3	2				
93.229	12.04	20.4	2.42				2	1	2	3	3	1				
94.071	16.22	19.92	1.89				1	2					3	3	3	2
94.129	10.76	18.06	1.76	53.22	45.75	3.74	2	2	3	3	3	2	3	3	3	1
94.137	12.1	20.7	1.9				2	3	2	3	3	1				
97.024	12.92	22.68	2	51.19	45.52	2.84	2	2	2	3	3	2	2	3	3	1
97.187	10.56	18.44	1.72	36.71	26.08	5.32	1	2					2	3	3	3
97.220	11.45	22.44	3.19	50.18	42.15	4.02	2	2	1	2	2	1	3	2	2	1

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
7.86	9.72	21.77	2.96	40.54	33.54	3.5	3	2					2	3	3	2
23.94	13.52		1.63	61.19	55.42	2.89	2	3	3	3	3	2				
86.086	9.71	17.21	2.03	38.74	31.83	3.46	2	2	3	3	2	3	3	3	3	2
87.032	9.48		2.5				3	3								
92.070	11.7		2.32				3	1								
93.086	8.15		1.11				2	3	3	3	3	2				
94.187	9.7	17.38	1.72				1	1								
95.044	10.19	18.45	1.92				1	1								
96.079	11.7	18.43	1.02				1	1								
11.9	9.21		2.16				3	3								
87.024a	13.38	24.56	3.39				3	1								
87.064a	13.84	21.09	2.81				1	1								
87.082	12.48	22.69	2.42				1	2					3	2	3	2
89.094	10.05	22.97	1.53	57.17	48.68	4.25	2	2	2	3	3	3	1	3	3	1
92.129	12.47		2.96	47.04	38.11	4.47	2	3	1	3	3	3				
92.157	11.08	21.24	2.02				1	2					3	2	3	2
94.174	12.05		2.12	42.51	35.03	3.74	3	3								
95.058	11.75	22.76	2.8				1	1								
95.196	11.43	22.5	1.62				1	1								
96.193	11.08	23.85	1.88	35.35	27.84	3.76	2	2	3	3	3	1	2	2	3	1
97.158	11.86	25.95	2.53				2	2	2	3	3	2	2	3	3	2
98.028	14.3	23.78	3.26	59.35	50.44	4.46	2	2	3	3	3	1	3	3	3	1
98.072	9.23		1.81				3	3								
24.88	11.56		1.91				3	3								
3.91	9.62	22.77	2.19				1	2					3	3	3	2
31.93	11.87		1.99	56.42	48.47	3.98	3	3								
00.18f	9.51		2.35				2	3	3	3	3	1				
92.044	10.04	16.19	1.43				1	1								
92.114	8.34		2.47	51.73	43.3	4.22	2	3	3	3	3	1				
95.086	10.75		1.83	38.82	32.03	3.4	2	2	3	3	3	2	3	3	3	2
96.198	11.66	21.07	3.04				2	1	2	3	3	2				
86.076a	10.26	21.52	3.11				1	2					1	3	1	1
87.051	9.3		1.59	44.24	38.54	2.85	3	3								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
88.018	9.1	21.62	2.96				1	1								
89.026	11.56		1.6	54.65	46.52	4.07	3	3								
89.035	11.98	22.28	3.2				1	2					3	2	3	2
89.090	11.38		2.58				3	3								
92.021	10.2	20.45	2.85				1	1								
92.054	11.53	18.72	2.24				1	1								
92.118	10.82	24.78	2.54				1	1								
92.122	9.86	20.61	2.28				1	2					1	3	3	1
93.012	14.7	23.23	3.7				2	1	2	3	3	1				
94.123	12.03	22.11	2.07				1	1								
95.145	9.96		2.43	44.22	37.98	3.12	3	3								
95.192	11.96	21.98	2.53				2	1	2	3	2	1				
96.069	13.33	24.52	2.14	51.71	41.14	5.29	1	2					1	2	2	1
96.103	11.23	18.78	1.7				1	1								
96.105	11.47	20.9	2.79	52.18	44.69	3.75	2	1	2	2	2	2				
97.116	12.6	23.48	2.56	53.76	45.65	4.06	2	2	2	2	2	1	3	3	3	2
98.045	11.26	22.7	2.27	51.14	42.51	4.32	2	2	2	2	2	1	1	2	2	1
6.87	15.25		1.43	31.08	21.89	4.6	2	3	3	3	3	1				
96.158	7.61		1.93	46.46	41.01	2.73	3	2					3	3	3	1
97.079	7.97	19.15	1.36				1	1								
00.28f	8.44		1.59				3	3								
87.016	14.12	21.53	3.17				1	1								
88.016	13.07		2				3	3								
88.037	11.05	17.2	1.88				1	1								
88.072	9.62		2.74	50.33	44.34	3	3	3								
89.017	13.6	23.19	2.23				1	1								
89.018	11.08		2.75	48.96	41.84	3.56	3	3								
89.046	10.83		2.3				3	3								
93.158	11.71	23.61	2.19				1	1								
94.083	10.44	20.89	2.11				1	2					3	3	3	1
94.153	11.93		2.45	49.89	42.84	3.53	3	3								
95.018	11.03	22.1	3.3				2	2	2	3	2	1	2	2	3	1
95.078	11.78		2.42				3	3								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
96.130	11.28	23.89	2.69	49.53	40.63	4.45	2	2	3	3	3	2	3	3	3	2
97.069	10.87		1.96				2	3	2	3	3	2				
98.032	9.67	23.32	2.28				1	1								
8.91	12.71	21.64	2.33				2	2	2	3	3	2	3	3	3	2
12.91	13.06	27.14	2.74	51.08	39.09	6	2	2	2	2	2	1	3	3	3	1
92.041	9.85		2.18	42.39	33.79	4.3	3	3								
92.123	10.23	18.72	1.08				1	1								
1.88	9.39	17.22	2.01				1	1								
7.95							1	1								
87.001	10.91	21.75	2.9				1	1								
94.193	9.33	19.72	1.8				1	1								
96.139	9.73	22.56	2.25				2	2	1	3	3	1	3	3	2	1
96.236	9.74		2.35				2	3	3	3	3	2				
87.013	9.61	17.26	1.74				1	1								
96.200	8.64	14.66	1.9				1	1								
87.002a	10.01	26.54	1.7				2	1	3	3	3	2				
87.046	12.08	27.26	2.31				2	2	3	3	3	2	3	3	3	1
87.047a	12.82		2.43	42.81	35.8	3.51	3	3								
87.048	10.15	22.64	2.22				1	1								
87.096	11.84	22.82	3.12				2	2	2	3	3	2	1	2	2	1
87.151	9.93		2.62	46.04	36.78	4.63	3	3								
88.068	11.66		2.97	44.2	39.5	2.35	3	3								
88.084	10.7		2.25				3	3								
88.150	10.35	18.76	2.24				1	1								
89.013	9.44		2.29	47.8	42.1	2.85	2	3	2	3	3	2				
92.113	11.14	22.71	2.45				2	1	3	3	3	1				
93.109	11.48	20.45	2.47				1	1								
93.114	9.78	21	1.84				1	1								
93.154	11.78	24.39	2.14				1	1								
94.140	10.6	23.39	2.07	49.45	41.08	4.19	1	2					3	3	3	2
94.163	11.59	22.71	2.89				1	1								
95.168	8.96		1.88	45.54	36.45	4.55	3	2					2	2	3	3
96.095	11.86		1.69				3	3								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
97.202	10.25		1.87				3	3								
89.057	11.06	17.05	1.98				1	1								
94.030	10.11	17.19	1.49	44.25	36.04	4.11	2	2	2	3	3	1	3	3	3	1
95.002	9.09		1.81	49.52	43.89	2.82	3	2					2	3	3	2
96.150	8.07	14.78	1.5				1	1								
87.002	10.89	19.6	2.65				1	1								
87.097	10.37	22.62	2.51	51.73	42.68	4.53	2	2	3	3	3	1	3	3	3	1
87.101	12.13	23.92	2.47				2	2	1	3	3	1	1	1	1	1
89.077	11.2		2.28				3	3								
93.031	10.54	21.07	2.4				1	1								
93.155	11.64	23.16	2.53				1	2					2	3	3	1
93.172	10.06	22.03	1.97				2	1	3	3	3	2				
94.074	12.55	19.65	1.38				1	1								
95.013	12.17	21.72	2.12	51.2	43.1	4.05	2	2	3	3	3	2	2	3	3	2
95.016	9.36		1.8	47.59	40.3	3.65	3	2					2	3	3	3
97.066	11.24		2.33				2	3	2	3	3	2				
1.81	8.44	23.38	1.89				1	1								
22.93	12.42	22.48	2.48				1	1								
45.93	12.71		2.17	47.09	39	4.05	3	3								
19.99	10.34	22.72	2.47				1	2					2	3	2	1
87.008a	9.66	21.91	2.26				1	1								
87.025a	11.75		2.61				3	3								
87.026a	12.1		3.25				2	2	3	3	3	1	3	3	3	1
87.042a	11.48		2.93		40.02		3	3								
87.109	10.69	21.49	1.93				1	1								
92.087	9.99		2.41	48.36	38.79	4.79	3	3								
92.178	11.1		2.6	40.66	32.05	4.31	3	3								
94.009	8.5	21.12	1.36				2	2	3	3	3	2	3	3	3	2
96.034	10.78	18.67	1.91				1	1								
96.035	9.88		2.28	44.63	33.55	5.54	3	3								
96.244	12.1	20.12	1.91				1	1								
97.055	11.59	22.41	2.66				1	1								
97.198	10.72	17.79	2.53				1	1								

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
97.218	10.31		2.73				2	3	2	3	3	2				
88.012	9.74	18.33	1.84				2	1	3	3	3	2				
94.015	8.28		1.58				3	3								
94.024	9.66	18.63	1.86				1	1								
94.157	6.11	16.44	2.11				1	1								
92.120	9.86	23	2.56	57.37	47.03	5.17	1	2					1	3	3	1
94.159	9.15		1.85	60.83	49.89	5.47	3	3								
95.034	9.09	19.24	2.64				1	1								
95.212	13.01	21.13	2.27				2	1	1	2	1	1				
88.081	9.23	17.72	2.44				2	1	2	3	2	2				
93.069	8.04	15.53	2.65				1	1								
94.181	11.12	21.4	1.65				1	1								
97.093	8.73	17.01	1.77				1	1								
20.91	8.19	17.66	1.66				2	2	3	3	3	2	3	3	2	2
93.007	10.36	18.38	2.2				2	1	2	3	3	2				
94.167	14.59		2.87	51.39	44.45	3.47	2	3	2	3	3	3				
95.003	9.66	20.62	2.17				1	2					1	2	1	1
95.132	10.09	22.11	1.85				2	2	2	3	3	2	3	3	2	3
98.005	11.74		3.61				3	3								
10.87	12.65		2.08	48.22	40.27	3.98	3	3								
23.93	10.3	20.35	2.76				2	1	1	2	3	3				
92.106	8.89		2.21				3	3								
96.055	8.34	18.19	1.52				1	1								
96.091	9.17	17.43	2.01				2	1	3	3	3	2				
98.014	8.22		2.53	48.47	41.12	3.68	3	2					2	2	3	2
87.036	12.21	22.67	3.49				1	1								
93.033	9.44		1.2	50.08	41.94	4.07	3	2					2	3	3	3
94.037	10.05		3.05				3	3								
94.082	11.59	25.14	2.11	52.97	45.07	3.95	2	2	1	2	1	1	2	2	2	1
96.251	13.73		2.05	55.39	46.21	4.59	3	3								
97.040	11.4		2.4	44.48	36.32	4.08	2	3	3	3	3	2				
98.009	9.27		1.72				3	2					3	3	2	3
25.91	9.83		2.8				3	3								

Specimen	BH	BW	BT	GHS	GHD	MTT	LHF	RHF	L1	L2	L3	L4	R1	R2	R3	R4
88.046	8.76	18.27	2.36	46.06	39.29	3.39	2	2	2	3	3	2	2	3	3	1
93.153	8.74	21.56	1.7				2	2	2	3	3	2	2	3	3	2
01.28f	10.72		1.96				2	3	3	3	3	1				
86.077a	10.14	25.17	1.99				3	1								
87.004a	13.63	20.45	2.71	39.48	33.43	3.03	2	2	3	3	3	2	3	3	3	2
88.096	10.02		1.66	34.19	25.38	4.41	3	3								
88.147	9.48	20.01	2.4				1	1								
89.042	12.27	19.89	2.08				2	1	3	3	3	1				
89.062	10.91	21.23	2.27				1	1								
92.062	11.52		3.09				3	3								
92.159	10.46	20.66	2.56				1	1								
97.121	12.73	22.72	2.05	44	34.9	4.55	2	2	2	2	2	1	2	2	2	1
22.9	13.55	22.01	2.15				1	1								
18.93	9.39		2.27				3	3								
87.031	8.66		1.66				3	3								
88.143	17.2		1.77	42.45	36	3.23	3	3								
96.129	7.43		1.87				2	3	3	3	3	2				
98.057	10.05	21.68	1.22				1	2					2	2	2	1
87.010a	10.66	24.35	2.53				2	2	3	3	3	1	3	3	3	2
87.014a	11.57		2.23	45.58	36.58	4.5	3	2					3	3	3	2
87.029	12.2		3.43	46.34	39.37	3.49	3	3								
87.055	9.33	22.36	2.06				1	1								
93.173	9.99	18.81	2.21				1	2					3	3	3	2
97.080	10.89	21.39	1.86				2	2	2	3	3	1	2	2	3	2
97.122	12.12	21.73	1.92	48.19	41.18	3.51	2	2	2	2	3	3	2	2	2	3
1.97	11.53	22.19	2.72				2	2	2	3	3	2	2	3	3	2
87.104	9.72		2.21	45.7	38.13	3.79	3	3								
87.143	8.82		2.25				3	2					2	3	3	1
95.006	9.16	19.63	2.17				2	1	1	2	3	1				
6.93	10.56		2.04	47.45	39.47	3.99	3	3								
87.002p	11.62	21.49	2.14				2	1	3	3	3	2				
87.021a	12.13		1.69	40.69	39.47	0.61	3	3								
87.033a	11.2	21.6	2.09	42.66	37.07	2.8	2	2	3	3	3	2	3	3	3	2

Specimen	*BH*	*BW*	*BT*	*GHS*	*GHD*	*MTT*	*LHF*	*RHF*	*L1*	*L2*	*L3*	*L4*	*R1*	*R2*	*R3*	*R4*
93.070	10.23	21.64	1.68				1	2					3	3	3	2
94.204	9.35	18.73	0.81				1	1								
95.009	9	22.28	1.8				1	2					1	2	1	1
95.010	9.26		1.62	44.06	38.07	3	3	3								
95.180	10.75	21.14	2.72	53.85	44.75	4.55	2	2	1	2	2	1	1	3	2	1
97.086	11.85		2.21				3	3								
98.069	11.76	21.93	2.59				1	2					1	2	2	1
87.069	10.84	17.2	1.9				1	2					2	3	3	1
87.131	10.05	18.65	2.56	47.1	39.25	3.93	2	2	3	3	3	1	2	3	3	1
88.031	10.42	17.44	2.03				1	1								
95.206	10.5	16.27	1.34				1	1								
96.148	8.53	16.17	2.05				1	1								
97.045	8.51	17.36	1.46				1	1								
97.049	10.35	16.17	2.41				1	1								
87.031a	13.59	24.69	1.46				2	2	3	3	3	1	3	3	3	1
93.162	11.76		2.37				2	3	3	3	3	2				
96.093	11.75	23.12	1.74				1	2					2	3	2	1
89.068	8.46		2.08				3	3								
87.022a	11.05	19.31	1.9				2	1	2	3	3	2				
87.061A	10.1		2.21				3	2					3	3	3	2
88.058	11.86		2.41	35.37	29.92	2.73	3	2					3	3	3	2
92.017	8.36		1.85				3	3								
95.007	9.51		2.05	41.93	35.19	3.37	3	3								
95.123	8.2	18.32	1.27				2	1	2	3	1	1				
96.073	8.89		2.11	48.16	39.73	4.22	2	3	2	3	3	1				
87.158	13.3	22.84	2.72				1	2					3	3	2	1
96.098	13.11		2.02	34.69	27.85	3.42	3	3								
96.121	10.47	23	2.04	49.04	44.27	2.39	2	2	1	3	3	1	1	2	3	1
97.020	11.48		2.05	45.66	38.15	3.76	3	3								
17.97	9.6	18.65	1.85				2	2	1	3	3	1	1	3	3	1
87.086	11.2		2.64	42.71	35.5	3.61	2	2	3	3	3	1	1	3	3	3
88.023	11.87		2.4				3	3								
93.059	9.24		2				3	2					2	3	3	3

Specimen	***BH***	***BW***	***BT***	***GHS***	***GHD***	***MTT***	***LHF***	***RHF***	***L1***	***L2***	***L3***	***L4***	***R1***	***R2***	***R3***	***R4***
93.223	10.71		2.43	45.97	39.11	3.43	2	1	2	3	3	2				
97.184	11.39	21.66	2.47				1	1								
15.93	11.73		3.08	42.65	35.14	3.76	2	3	3	3	3	2				
95.127	9.37		1.67				2	3	3	3	3	2				
96.074	8.59		1.74	44.89	37.71	3.59	3	3								
01.27f	8.77		1.96				3	2					3	3	3	2
93.020	9.01	21.82	2.45	46.21	38.35	3.93	2	2	3	3	3	2	3	3	3	2
97.041	10.86		2.22	47.27	38.64	4.32	3	3								
97.156	11.75	22.01	2.93	54.56	46.88	3.84	2	2	1	3	2	1	1	3	3	2
88.014	10.95	17.3	2.74				2	2	1	3	3	1	1	3	3	1
95.111	8.95		2.1	54.33	47.84	3.25	3	3								
97.199	10.83	19.85	1.82				1	1								
00.40f	12.25		2.49				3	3								
96.056	10.49	19.5	2.03	44.53	36.25	4.14	2	2	2	3	3	2	2	3	3	2
96.176	8.22	16.52	1.97				2	2	3	3	3	1	3	3	3	1
98.022	8.8	11.02	1.5				1	1								
89.097	10.63	18.44	1.83				1	1								
94.150	11.51	18.94	2.14				1	1								
2.85	9.98	21.08	2.4	60.28	52.01	4.14	2	2	3	3	3	2	3	3	3	2
87.035	8.24	18.98	2.2	43.44	36.33	3.56	2	2	2	3	3	2	1	3	3	1
92.104	8.27	18.5	1.56				2	1	2	3	3	1				
97.193	12.78	20.82	2.05				1	1								
98.067	9.14	14.32	1.61				1	1								
21.94	10.27	28	1.43	59.05	52.2	3.43	2	2	2	3	3	1	2	3	3	1
87.017a	9.95	26.61	2.3				1	1								
87.045	9.99		2.61				3	3								
94.192	9.38	15.87	2.43				2	2	2	3	3	3	2	3	3	3
95.148	9.88	18.31	2.31				2	1	2	3	2	1				
87.006a	8.64	21.08	2.71				1	1								
87.055a	10.74		2.38	48.08	42.07	3.01	3	3								
97.215	7.77	15.7	2.01				2	2	2	3	3	1	3	3	3	2
4.94	8.99		2.04	44.18	37.73	3.23	3	3								

Vita

Joanne Lorraine Devlin (nee Bennett) was born in the late 1960's at the University of Chicago Medical Center, with her formative years spent in New York. Before her tenth birthday, she was first exposed to anthropology; fascinated by a text book that belonged to her mother. The second encounter followed shortly thereafter involving an elementary school project focusing upon African peoples. It was for the next decade, however, that this interest would lie unrealized owing to the pressures of middle school and high school. Graduating from Pleasantville High School in the mid 1980s, Joanne headed upstate, to Hamilton College where she soon came face to face with professional anthropologists. Once again enticed by the discipline, she gave and dedicated her undergraduate career to the study of prehistoric archaeology and anthropology.

Upon earning her bachelors degree, Joanne sought employment in the arena of contract archaeology. After too many unpleasant days in the field and too many cold winters she headed to Knoxville to seek her fame and fortune or a graduate degree in anthropology. This was realized in the summer of 1996 with the completion of the MA program. During the years that followed she diversified her interests; partaking in many non academic activities while completing the requisite course work for the doctoral program. In the winter of 1999, Joanne was married to Jeffery C. Devlin, who was a source of amazing support throughout the final and not so glamorous, academic hurdle; the writing of this dissertation.