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Descriptions of Dwarfism in the Skeletons of Two Individuals from the Robert J. Terry Anatomical Skeletal Collection

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Abstract

This paper describes two individuals from the Robert J. Terry Anatomical Skeletal Collection housed at the National Museum of Natural History in Washington, DC (TC 300R and TC 1636). Both of these individuals are documented to be dwarves (specifically pituitary dwarves), but the presentation of dwarfism in the skeleton differs between the two. In this paper, two individuals are described, first by discussing background and demographic information, and then by describing the skeletal material. This study describes and discusses morphology (looking at metric and non-metric traits) as well as pathological conditions and the preservation of the skeletal material. This paper does not attempt to diagnose any pathological conditions—conditions that have been diagnosed in each individual are noted and the analysis is limited to description. A portion of the paleopathological literature on skeletal dysplasias is reviewed, along with recent theoretical developments in biocultural anthropology. This paper concludes with a comparison of the manifestation of dwarfism in each of the individuals examined and a brief discussion of life histories.

Introduction

The Robert J. Terry Anatomical Collection, currently housed at the National Museum of Natural History, includes many individuals with documented pathological conditions (Hunt and Albanese 2005:406). Two individuals, catalog numbers 300R and 1636, have been identified as dwarves (Terry Collection records). This essay will discuss the background of the collection and of the individuals examined. This paper will also include descriptions of each of these individuals, including inventory, documentation of pathological conditions, and taphonomy. I also contextualize this research within theoretical developments on the biocultural side of physical anthropology and I discuss relevant paleopathological and clinical literature on dwarfism.

The Robert J. Terry Anatomical Collection is widely used for research in physical anthropology. The individuals were first used as dissecting cadavers for medical students at Washington University in St. Louis (Hunt and Albanese 2005:407). Afterwards, they were processed to remove all soft tissue (Hunt and Albanese 2005:408). Most of the individuals in this collection come from local morgues and were unclaimed for burial (Hunt and Albanese 2005:407). The passage of the Willed Bodies Act in 1956 influenced how cadavers eventually came to be in the collection (Hunt n.d.). One individual examined here (TC 300R) was added to the collection before 1956 and another individual was added after (TC 1636).

Morgue records are associated with the individuals in the Terry Collection and provide information about the age, sex, ancestry and death circumstances of each skeleton (Hunt and Albanese 2005:411). Morgue records show that TC 300R was a white female that died in (need date). The records indicate that she had "hypostatius" and that she was a pituitary dwarf (Terry Collection records 300R). TC 1636 was a black female, aged 59 who died in 1959. The records indicate that she had "ashd fret," which could be a cardiovascular disease (Terry Collection records 1636).

Theory

Theory and method in biological anthropology have evolved throughout the history of the discipline. Armelagos and Van Gerven (2003) trace the development of the field throughout the twentieth century, from the focus on race in the early years to the current focuses on functional anatomy and bioarchaeology. Zuckerman and Armelagos (2011), as well as Zuckerman et al. (2012) also provide a review of theoretical and methodological developments in physical anthropology, chronicling the emergence of the biocultural approach. Armelagos and Van Gerven (2003) discuss the "new" and "old" physical anthropology, where "new" refers to biocultural and functional approaches, and "old" refers to descriptive approaches (Armelagos and Van Gerven 2003:59). S.L. Washburn (1951) originally introduced the term "new physical anthropology." The authors conducted a survey and found that descriptive papers were actually more common in recent years, which could reflect an overall shift back to the "old" physical anthropology (Armelagos and Van Gerven 2003:59-60).

They also offer their vision of the future of physical anthropology: "…we have to reclaim skeletal biology as the means to understand morphology from a functional perspective and adaptation and evolution from a biocultural perspective" (Armelagos and Van Gerven 2003:62). Additionally, they advocate for taking this a step further and using skeletal biology as a means of addressing questions concerning inequality (Armelagos and Van Gerven 2003:62). Others have similarly argued that evolutionary theory can be incorporated into biocultural approaches in order to address questions about not only biological, but also social aspects of disease (Zuckerman et al. 2012:51). Osteobiography fits into these visions of biological anthropology.

Osteobiography is an approach in current theory in biological anthropology (Agarwal and Glencross 2011, Grauer 2012, Stodder and Palkovich 2012). Frank Saul uses the term "osteobiography" in his 1972 publication *The Human Skeletal Remains from Altar de Sacrificios: An Osteobiographic Analysis*. In this book, he outlines questions that can be addressed using this method, including: "who was there? What happened to them? What can be said about their way of life?" (Saul and Austin 1972:4:Figure 1). He also lists skeletal information from individuals that can help get at these questions, including: "age at death, sex, dimensions…discrete traits… and pathology" (Saul and Austin 1972:4:Figure 1). In the original publication, these questions were applied to a Maya population (Saul 1972).

Another publication on the same population group provides more examples of applications for osteobiography (Saul and Saul 1989). In this case, context is extremely important in piecing together the lives of these individuals. The authors draw on material culture in addition to the skeletons to make inferences about class (Saul and Saul 1989:291-292). They examine cultural body modification practices to make inferences about the society at large (Saul and Saul 1989:293-294). They also emphasize the utility of forensic techniques in an archaeological context (Saul and Saul 1989:301).

Stodder and Palkovich's (2012) book provides several examples of osteobiographies. The editors describe the layout of the book in terms of the construction of an osteobiography, which is "… the study of an individual beginning with the skeleton and then expanding the analytical and interpretive scale from the grave outward to understand this person's context in life and in death" (Stodder and Palkovich 2012:1). Agarwal and Glencross (2011) also review the development of bioarchaeology. They use the term "skeleton up" to describe the way bioarchaeologists can build an analysis of skeletal remains (Agarwal and Glencross 2011:3). Several dissertations (see Boutin 2008 and Renschler 2007), as well as contributions to edited volumes (Agarwal and Glencross 2011, Stodder and Palkovich 2012) have made use of this approach. Most, if not all of these papers have used osteobiography to analyze individuals from archaeological samples (not from anatomical collections).

As with all methodological and theoretical approaches, osteobiography has advantages and disadvantages. Advantages include: rigorous description and the reconstruction of life histories. An emphasis on standardized methods for collecting data, while not limited to osteobiographical approaches, is also important (Zuckerman et al. 2012:46). Stodder and Palkovich (2012) highlight that this approach focuses on individuals rather than populations, making it different from theory and method of the past (1-2).

This method is more relevant in some contexts than in others, and can be very difficult to apply to certain kinds of skeletal material. In anatomical collections like the Terry Collection, depending on the level of documentation, context can be difficult to work out or reconstruct. This is less of a problem for archaeological sites, where material culture and burial practices can aid in analysis (see examples in Stodder and Palkovich 2012). Most of the literature on osteobiography focuses on bioarchaeology and archaeological samples, not on anatomical collection samples, where reconstructing context requires a different approach. Material culture is usually not associated with anatomical collections, even though other historical or documentary information may be available. Many osteobiographies rely on material culture and the reconstruction of burial practices (see examples in Stodder and Palkovich 2012).

There is also a danger of over-interpretation in this approach. Alexis Boutin's (2008) dissertation used osteobiographical methods and social theory to write fictional narratives about the individuals in the skeletal collection from Alalakh. While Boutin (2008) clearly states that the stories are not intended to be true, she still believes that they have value (6-7, 60). Her dissertation pushes theoretical boundaries, but these narratives are problematic in that they take the osteological data and interpret it beyond its limits.

Susan Pfeiffer (2003) also used osteobiographical analysis on the Moatfield Ossuary project. She provides a particularly salient critique of this method, writing, "we need to be particularly cautious, because… studying the osteobiography of people from the deep past has no final verification that 'we got it right.' The only confirmation is the weight of evidence over many such studies… and corroboration from other disciplines and approaches" (Pfeiffer 2003:163). Her critique is a reminder that interpretations based on skeletal remains are merely that, *interpretations*. Following her concerns, I follow the osteobiographical method with caution in this project.

For this paper, osteobiography has limited applicability. All the descriptions in this paper are based on gross-level non-invasive techniques, so the questions about life histories that can be addressed are limited. The lack of contextual information is also a problem. In the case of the Terry Collection, there are morgue records for individuals but they are variably complete (Hunt and Albanese 2005:411). Archival and other historical research could aid in fleshing out life histories and making up for the lack of information in the morgue records. There is no material culture associated with the individuals studied in this paper.

Even though there are limitations to the application of osteobiography to anatomical collections, aspects of the theory and method are applicable to all aspects of biological anthropology research and are certainly relevant to this paper. The emphasis on the study of individuals as opposed to populations (or large samples) and on description is useful in this project. In this vein, this paper focuses on descriptions of individuals. The interpretations based on the descriptions are much more conservative than in many other osteobiographies (Stodder and Palkovich 2012, Boutin 2008), because of the difficulty of reconstructing context.

Paleopathology Literature

The paleopathological literature on dwarfism and other skeletal dysplasias points to the multitude of factors that can cause an individual to be reduced in size (Waldron 2009, Ortner 2003). The clinical literature also shows the multitude of skeletal disorders that affect humans (Papadatos and Bartsocas 1982). Ortner (2003) describes the ways in which pituitary dwarfism specifically can present in the skeleton. Hypopituitarism, a condition that has been attributed to TC 300R (Terry Collection records 300R), affects the skeletal system only in the case of a pituitary disturbance during childhood (Ortner 2003:422). This condition is described as a "reduced growth in length and width of the bones" (Ortner 2003:422). Additionally, epiphyses and cranial sutures do not close as they normally would; they close at a slower rate (Ortner 2003:422). The skeletal elements are proportional, but smaller in size than in a normal individual (Ortner 2003:422).

Waldron (2009) also discusses the ways in which disorders in growth and development can affect the skeleton. In his discussion of dwarfism, he cites for conditions that can result in dwarfism, including: "achondroplasia, Turner's syndrome, lack of growth hormone… and inadequate nutrition" (Waldron 2009:195). Waldron points to several features of skeletal dysplasias, including: "abnormal shape or size of the skeleton, increased or decreased number of skeletal elements; and abnormal bone texture as the result of an increase or decrease in bone remodeling and mineral deposition" (2009:198). He also describes how these conditions can affect the shape of skull (Waldron 2009:198).

In his discussion of pituitary dwarfism, Waldron mentions that there are no definite skeletal indicators of the condition (2009:196). Unlike Ortner (2003), he does not include a discussion of epiphyseal fusion. Waldron suggests that the best way to confirm pituitary dwarfism would be to demonstrate that it is drastically smaller than other individuals in the population, but that it is still in proportion (2009:196). Charlotte Roberts (1987), using a similar approach, describes a potential case of pituitary dwarfism in a Roman population. The criteria she used for diagnosing the case focused on the proportions of the long bones and the lack of complete epiphyseal union (Roberts 1987:1659). In this paper, I will demonstrate that both individuals are significantly shorter than other individuals in the Terry collection. To do this, I will compare maximum lengths on long bones from individuals of normal stature with maximum lengths from 300R and 1636.

There have been several other publications that looked at cases of dwarfism in various populations (Hernandez 2011, Slon et al. 2011, Dasen 1988, Ortner and Hotz 2005). These papers explore various forms, including hypopituitarism (Hernandez 2011), hypothyroidism (Ortner and Hotz 2005) and achondroplasia (Slon et al. 2011). Dasen (1988) provides an overview of different forms of dwarfism and the ways in which it has been viewed culturally. The studies that treated skeletal remains are case studies (Hernandez 2011, Slon et al. 2011, Ortner and Hotz 2005).

Hernandez (2011) uses the term “restricted growth” instead of dwarfism in her analysis (1-2). The individual who is the focus of this paper (M53) comes from an archaeological site from the Neolithic period in Henan Province in China (Hernandez 2011:2-3). This individual had unfused epiphyses on the long bones, making it difficult to age (Hernandez 2011:6). Due to the proportionality of the limb bones, this individual was diagnosed as having PSS (Hernandez 2011:10) and hypopituitarism (Hernandez 2011:11).

Slon et al. (2011) describe an individual with dwarfism from Israel. The authors use both metric and non-metric analyses to come to a diagnosis of achondroplasia (Slon et al. 2011:14). They also provide a historical context for this individual, discussing how a dwarf may have been regarded socially during Byzantine times (Slon et al. 2011:14-15). Finally, the authors acknowledge the difficulties of diagnosing achondroplasia in the skeleton (Slon et al. 2011:15). They also advocate exercising a “prudent approach” in interpreting skeletal remains, both in terms of diagnosing pathological conditions and in discussing the social context of the remains (Slon et al. 2011:15).

Ortner and Hotz (2005) present cases of hypothyroidism from the Galler collection, some of which are dwarves. The article points to hypothyroidism as a reason for individuals being reduced in size, and the authors emphasize differences in the skeletal manifestations of hypothyroidism and achondroplasia (Ortner and Hotz 2005:5). The authors also note that epiphyseal fusion often occurs later in individuals with hypothyroidism (Ortner and Hotz 2005:6). They also highlight the effect that hypothyroidism had on the postcranial elements as opposed to the skull (Ortner and Hotz 2005:6).

Ortner (2003) discusses two possible cases of pituitary dwarfism in Smithsonian collections, NMNH 314306 (from a Native American population) and NMNH 379510 (from Peru). The characteristics of NMNH 314306 are similar to those discussed earlier in the chapter. They include: incomplete fusion of epiphyses, abnormal dental development, and an abnormally shaped skull (Ortner 2003:424). Although all the bones are reduced in size, the individual shows normal proportions (Ortner 2003:424). NMNH 379510 is a skull (no postcranial elements), which could also be a pituitary dwarf (Ortner 2003:424).

Dasen (1988) traces the depiction of dwarves throughout history and also provides an overview of different types of dwarfism. She shows that dwarves often had a special place in Mediterranean societies (Dasen 1988). This article provides a discussion of how dwarves were regarded in the past, using artwork and writing (Dasen 1988). The significance of this paper lies in how discusses how biology and medicine were dealt with in culture.

Materials and Methods

This project focused on doing gross-level, non-invasive, non-destructive skeletal analysis of two individuals, TC 300R and TC 1636. I used standard sliding and spreading calipers, a tape measure and an osteometric board to take the linear measurements. I followed the measurement protocol laid out in Buikstra and Ubelaker (1994)'s *Standards* book. I also followed the non-metric traits recording form included in the book. I took note of the skeletal indicators of dwarfism and other dysplasias as described by Waldron (2009). In doing this, I calculated ratios that I felt would be helpful in describing shape differences metrically. I used Excel for Mac 2008 to calculate the limb proportion ratios and SPSS to calculate the descriptive statistics.

For the descriptive portion of the paper, I concentrated on describing abnormalities in bones shape and texture, as well as formation and loss. I make cautious inferences about how observed pathological conditions could have affected these individuals. In other words, I follow portions of the osteobiographical approach, while making less extensive interpretations.

I also took a small sample of other Terry Collection individuals to use for comparative purposes. This sample included the following: TC 208 (a black female), TC 289R (a white female), TC 815 (a black female), TC 1153 (a white female), TC 1370 (a white female), TC 1555 (a black female), TC 1617 (a white female), TC 94R (a black female), TC 49R (a black male), TC 152 (a white male), TC 235 (a black male), TC 362 (a black male), TC 434 (a white male), TC 522 (a black male), TC 645 (a white male), and TC 908 (a white male). This sample was used when interpreting the ratios I calculated for different limb maximum lengths. This particular sample was also taken from individuals housed at the National Museum of Natural History. I focused on selecting a sample of non-pathological individuals. I calculated stature by using formulas in Bass (2005).

Descriptions and Non Metric Analysis

Terry Collection 300R

Cranial

The cranium of TC 300R is well preserved. The maxilla is edentulous and a portion of the alveolus is resorbed. The cranial sutures are not completely closed. There is also red staining and erosion of the area around the temporo-mandibular joint. The amount of resorption indicates that the anterior teeth were probably lost first. The mandible of TC 300R does preserve some of the dentition. Teeth present include the left third molar, the left second premolar, the left first premolar, the left canine, the right first and second premolars and the right first molar. The right first molar has a filled caries. The left first mandibular molar is also present but it is not contained in the alveolus. The coronoid processes are taller than the condyles.

Postcranial

The postcranial elements of TC 300R are well preserved, although no hyoid is present. There is an open epiphysis on the medial end of both clavicles, and the texture of the bone on the epiphyseal surface is abnormally rough.

There are also open epiphyses on both scapulae. The presence of open epiphyses in an individual with pituitary dwarfism is consistent with Ortner's (2003) description of effects of pituitary dwarfism in the skeleton. The open epiphyses include (on both sides) the inferior angle, the medial border, and the acromion process. On the left scapula, the epiphysis on the coronoid process has not completely closed. On the right scapula, there is some pitting in the glenoid fossa, as well as some lipping on the posterior portion of the margins and bone loss on the anterior superior portion of the margin. These changes (the pitting, lipping and bone loss) are indicative of arthritic change.

On both humeri, the epiphyses have not completely closed. The line where the epiphysis attaches to the diaphysis is still visible on about half of the way around the humeral head. The deltoid tuberosity is more rugose on the right humerus than on the left humerus. On both radii, the epiphyseal line is still visible on the distal end and halfway around the proximal end. The muscle attachments are more rugose on the right side. Epiphyseal lines are also visible on the distal ends of both ulnae. There is a small amount of lipping on the olecranon and coronoid processes of both ulnae. The increased rugosity of the muscle attachments on the right side could indicate that this individual was using her right side more often (right handed) or to do more strenuous tasks.

The manubrium and corpus sterni are not present. There are left and right ribs present, and the presence of growths on the rib ends indicate more advanced age. In terms of the spinal column, most vertebrae appear normal. The C5 and C6 vertebrae are fused. The T5 through T7 vertebrae are also fused. The sacrum also appears normal and is made up of five elements.

There are open epiphyses on both innominates. On both sides, these include: the iliac crest, pubic symphysis, and the ischial tuberosity. In the acetabulum on both the right and left sides, there is extensive lipping and osteophyte growth on the margins, as well as a combination of bone loss and gain inside the acetabulum. The lipping and osteophyte growth is more advanced on the right side. The changes in the acetabulum are consistent with arthritic changes, which could be due to activity.

Both femora also show indicators of arthritic change. There is extensive bone formation on both femoral heads, especially around the margins. There is also bone loss (erosion) on the superior medial portion of the femoral head. The line where the distal epiphysis fuses to the diaphysis is still visible on the posterior portion of the femoral condyles and on the greater trochanter of the left femur. There is also some bone loss on the distal articulation. The changes to the right femur resemble those from the left, but they are more severe. There is more bone formation on the femoral head, especially around the margins. There is more bone loss and also eburnation on the femoral head, as well as pitting and bone loss on the distal articulation. The combination of changes on the femoral heads and the acetabulum shows that there were extensive arthritic changes in both hip joints. Both patellae are present.

Both tibiae appear relatively normal, with the exception of their size. The muscle attachments are not rugose. On the right tibia, there is some bone formation on the margins of the tibial condyles. The fibulae also appear relatively normal in terms of shape. The epiphyseal line is still visible on the proximal ends of both fibulae.

The carpals, metacarpals and phalanges are all present and well preserved. The right capitate, hamate and trapezoid are fused together. The second and third metacarpals are also fused at the medial articulation of the second metacarpal and the lateral articulation of the third metacarpal. The fusion of these elements would have had some impact on the function of the wrist and hand. The right first and second cuneiforms are fused. Otherwise, the tarsals and metatarsals appear normal in terms of shape and are well preserved.

Terry Collection 1636

Cranial

The cranium of TC 1636 is well preserved. The maxilla is edentulous and the bone in the alveolus is resorbed. There is new bone growth concentrated on the posterior portion of both parietals. On the left parietal, the bone growth is on the medial side. On the right parietal, there is bone growth on the medial side (this growth is more extensive than on the left side). There is additional bone growth on the anterior and superior portion of the right parietal, close to bregma.

The most growth is concentrated almost directly above the lambdoidal suture. The mandible of TC 1636 is edentulous and the alveolus has been resorbed, although the resorption is more advanced towards the anterior portion of the mandible, indicating that the anterior teeth were lost earlier than the postcanine teeth.

Postcranial

The postcranial elements of TC 1636 are relatively well preserved. The hyoid is intact. There is abnormal bone texture on the medial ends of both clavicles. There is lipping and new bone formation on the margins of the glenoid fossa on both sides as well. On the right scapula, there is lipping and new bone formation on the margins of the glenoid fossa. The most extensive bone formation is on the inferior half of the glenoid, on the posterior side. The lipping and new bone formation is consistent with arthritic change, and one side does not show more extensive change than the other.

The arm bones also exhibit some signs of arthritic change. There is minimal lipping on the margins of the left humeral head. On the right humerus, there is new bone growth on the anterior superior portion of the greater tubercule. The deltoid tuberosity is rugose and the shaft is thicker than the shaft on the left humerus. The development of the muscle attachment sites indicates that this individual was probably right handed or at least using her right arm more often or to do more strenuous tasks. There is also a septal aperture on the left humerus.

There is a small amount of lipping on the distal end of the left radius. The distal end of the right radius looks similar, but the lipping is more extensive. There is also new bone growth concentrated in the center of the distal end, which could be evidence of a healed fracture.

The proximal end of the left ulna is curved medially. There is a small amount of lipping on the margins of the olecranon and coronoid processes. The proximal end of the right ulna is also curved medially. There is lipping on the margins of the olecranon and coronoid processes, similar to that seen on the left ulna. The lipping is more extensive on the margins of the coronoid process on the right side. There is also new bone growth in the center of the olecranon and lipping at the distal end. These arthritic changes are not very extensive.

The corpus sterni is present, but the manubrium is not. All ribs are present. The rib ends show signs of cartilage ossification. The vertebral column for 1636 is currently on display in the Written in Bone exhibit, and is described as having scoliosis (Owsley and Bruwelheide 2009). There is marked curvature of the spinal column consistent with the diagnosis of scoliosis.

The first sacral element is compressed on the right side. Both the right portion of the body and the right wing are compressed inferiorally. The preservation of the sacrum is not as good as that of the rest of the axial skeleton. The wings are broken off of the right second and third elements and the right and left fourth and fifth elements. The changes in the sacrum are consistent with the scoliosis in the vertebral column.

The right and left innominates also exhibit signs of arthritic change. There is lipping on the margins of the acetabulum on the left innominate, as well as bone loss in the acetabulum. There is bone formation on the auricular surface that could be ossified cartilage or other muscle tissue. The posterior inferior portion of the pubic symphysis is absent, as well as the anterior superior portion of the acetabular margin. The arthritic changes (lipping and bone loss) to the acetabulum are bilateral. There is also bone formation on the posterior superior iliac crest of the right innominate.

Both femora are very short in comparison with the other long bones, especially the tibia and fibulae. The tibiae and fibulae are longer than the femora. Both femora also have rugose muscle attachment sites, especially the lesser trochanter and the linea aspera. The fovea capitis is very large relative to the size of the femoral head. There is lipping and new bone formation on the condyles. The shapes of the condyles are not symmetrical between the left and right sides. On the left femur, the lipping around the margins of the condyles is more extensive on the posterior side. The area where new bone formation is most extensive is the distal anterior side. On the right femur, the lipping and new bone formation are most extensive on the posterior anterior side of the medial condyle. There are also small nodules of new bone growth superior to the medial condyle on the medial side. The linea aspera is more rugose on the right femur than on the left femur.

Both patellae are present. Both tibiae are bowed. The shafts are bowed medially at midshaft, and the proximal ends are curved laterally. On the left tibia, there is lipping on the margins of the tibial plateau. The lipping is more extensive on the medial side. There is also lipping on the margins of the tibial plateau on the right tibia, with the most lipping present on the posterior medial side. Overall, there is more extensive lipping on the right tibial plateau than on the left. The combination of lipping and new bone growth on the tibiae and femora indicate arthritic changes in the knee joint. Additionally, both fibulae are slightly bowed, consistent with the tibiae. The right fibula is missing the proximal end.

All elements from both the left and right hands are present and well preserved. There were no observable pathological conditions in the carpals, metacarpals or phalanges. The tarsals, metatarsals and pedal phalanges are not well preserved. The bones are very brittle and many are broken.

Metric Analysis

In this section, I discuss the metric analysis of 300R and 1636. I first discuss symmetry within each individual. Then I compare proportions in these individuals with the Terry sample of individuals of normal stature. The long bone measurements from non-dwarfed Terry individuals are analyzed as a group. These measurements are used to compare limb and long bone length proportions between individuals of normal stature and dwarfed individuals. I also discuss calculating stature from long bone length (and associated difficulties) for each of the dwarfed individuals.

Symmetry

300R is a fairly symmetrical individual in terms of maximum lengths of long bones (and flat bones such as the clavicle and scapula). The greatest difference in length is on the maximum length of the humerus, where the right humerus is 5 mm longer than the left. Otherwise, differences in lengths range from 3 to 4 mm. In all cases the right element has a greater maximum length than the left. Even though the femora measured the same length, there is extensive bone formation on the femoral heads, which could affect the measurements.

1636 shows more asymmetry than 300R. The right clavicle is 8 mm longer than the left clavicle, and the right scapula measures 7 mm higher than the left. Less significant differences in measurements include humeral maximum length (the left side is 3 mm longer than the right) maximum length of the radius (the left side is 4 mm longer than the right). The innominates also differ in shape, with the left side measuring 7 mm higher than the right, as well as 7 mm broader (iliac breadth). The right pubis measures 7 mm longer than the left side. Pubis length and ischium length are estimates due to the nature of the measurements. The greatest differences in measurement values are in the femora. The left femur is 6 mm longer than the right (maximum length), and the bicondylar length measurement differs by 12 mm. The difference in bicondylar length is significant because it indicates that the angle of the femur is different between sides. In general, this individual exhibits more asymmetry than 300R.

Proportions

The humero-femoral index clearly illustrates the differences in limb proportions between 1636 and the other individuals. 1636 has a humero-femoral index of 105 (taken from measurements on the left side), while all other individuals have indices well below 100 (high 60s and low 70s). The mean humero-femoral index value for all non-dwarfed individuals was 71. The humero-femoral index of 300R shows that, at least in terms of the humerus and the femur, the individual shows normal proportions (the value was 71, the same as the mean value). This is consistent with Ortner (2003)'s description of pituitary dwarfism. The value for 1636 is well outside of three standard deviations from the mean (105 versus 77.426). This shows that 1636 is not proportional, and therefore a less 'classic' case of pituitary dwarfism, or is perhaps not a pituitary dwarf at all.

The femur/tibia maximum length ratio illustrates the disproportionately short length of the femur on 1636. On both sides, the femur is 81% the length of the tibia (tibia-femur ratio of .81). 300R is closer to the mean value of all individuals measured, with the femur being 136% the length of the tibia. The mean index value for all other individuals was 121. In this case, the value for 1636 is also more than three standard deviations away from the mean index value (81 versus 111.9). This ratio further illustrates the disproportionately short lengths of the femora of 1636.

The knee joint (distal femur) is relatively wide compared with the length of the femur on 1636. To estimate the relationship between the width of the knee joint and the length of the femur, I divided the distal epiphysis breadth by the maximum length of the femur. In the case of this ratio, as in the tibia/femur maximum length ratio 1636 was different from 300R as well as from the other individuals. The ratio (multiplied by 100, for the left side only) for 1636 was 29 and for 300R it was 20. The average value for the other individuals measured was 17. In this case, the value for 1636 is more than three standard deviations from the mean value (29 versus 20.8), while the value for 300R is not. In 1636, the value for epicondylar breadth is similar to that value for other individuals, but since the femora are so much shorter, the knee joints are relatively wide in comparison with the other individuals.

In terms of the arm bones, both 1636 and 300R show proportions similar to the other individuals measured. I calculated the ratio of humerus maximum length to radius maximum length to see if there was a difference in the proportions of the upper arm to lower arm. In 1636, this index value was 120 and in 300R this value was 143. The average value for all other individuals was 133. Both of these individuals have an index value that is within three standard deviations of the mean value. This ratio shows that the arm bones for both dwarfed individuals are fairly close proportionately to the individuals of normal stature.

It is difficult to calculate stature for 300R and 1636, since Bass (2005) does not provide stature estimates for individuals with femora as short as those of 300R and 1636. However, it is possible to determine that 300R would have been below 55 inches tall, based on femoral maximum length. Since the femora for 1636 are so out of proportion, using them in a stature formula would probably not produce an accurate stature estimate. Calculating estimated stature using the humerus yields a height of 58 inches, and using the tibia, a height of 59 inches. It is unlikely that 1636 was this tall, given how short the femoral lengths are.

Even though the comparative sample is very small (n=16), it is clear that TC 300R shows proportions similar to individuals of normal stature, while TC 1636 does not. The femora of 1636 are especially out of proportion, especially in terms of the humero-femoral index, as well as the ratio between femur and tibia length. The distal ends of the femora are also wide for the length of the bones.

Discussion

Dwarfism and Proportions

The metric and non-metric analyses of both these specimens indicate that, although both of these individuals have been classified as pituitary dwarves, there way in which this condition has manifested in the skeleton is very different. 300R is a more ‘classic’ case of pituitary dwarfism, as it conforms to the definition provided by Ortner (2003); the individual is proportional, at least in terms of long bone lengths, and epiphyseal union is incomplete, even though the individual is an adult. 1636 does not exhibit these same traits. Although the individual is reduced in size overall, the limbs are not proportional. The femora are extremely short relative to the rest of the long bones. There are no open epiphyses either. The differences between these two specimens are indicative of the fact that dwarfism can manifest in the skeleton in a variety of ways. Since both of these specimens have been classified as pituitary dwarves, they show that even pituitary dwarfism can look very different depending on the individual, or that perhaps the diagnosis for 1636 needs to be re-evaluated.

Pathological Conditions and Life Histories

Each of these two individuals exhibits some pathological skeletal conditions. There are extensive arthritic changes in the hip joints of both individuals. There are also some arthritic changes in the shoulder joints, as well as in the elbow and knee joints. For the most part, these changes are either bilateral or more pronounced on the right side. 300R has dental caries and abnormal dental development among the teeth that are present. 1636 exhibits new bone growth on the parietals, which could be due to a variety of pathological conditions. Both individuals have lost either most or all of the dentition.

While, based on the lack of context for these individuals, it is difficult to reconstruct details about their lives, each exhibit skeletal markers that can be interpreted. For example, in both individuals, muscle attachments are more rugose on the right side, indicating that the right side was probably dominant. Muscle attachment sites on 300R, with the exception of the right deltoid tuberosity, are generally not very rugose. This individual was probably not engaging in strenuous activity. 1636 exhibits more arthritic changes and more rugose muscle attachments, which indicate a higher level of strenuous activity.

Challenges

Originally, I had intended to examine another individual, NMNH 314306. Ortner (2003) had used this individual as an example of how pituitary dwarfism is expressed in the skeleton. This individual is from a Native American population and is currently housed in the Repatriation Osteology Lab. I decided not to include this individual in my analysis for a number of reasons. Even though I still had permission to do research on it, I was uncomfortable examining this individual knowing that it was going to be repatriated. Since it had been written up and published already (Ortner 2003) I decided to include the previous analysis in my literature review rather than examining the individual myself. I decided to exclude the individual for ethical reasons.

Another challenge involved estimating age for 300R. There is no chronological or morgue age listed on the death records. Conventional methods for age estimation, with the exception of using the auricular surface, are impossible to use on this specimen. Many of the epiphyses are still open even though the individual is an adult, and the pubic symphysis cannot be used for aging because the epiphysis has not fused there, so it looks like a juvenile surface.

Tooth wear is not very helpful as all the maxillary dentition is gone, along with most of the mandibular dentition. The extensive arthritic changes could indicate a more advanced age, but estimating age is difficult. The best I could estimate was around 45 years, based off the arthritic change and the auricular surface. Discussing life history also becomes challenging when it is difficult to age an individual.

Conclusion

These two individuals are examples of the multitude of ways in which dwarfism can be manifested in the skeleton. The comparisons between the individuals show the complicated nature of skeletal dysplasias. In keeping with portions of the osteobiographical approach, I have done exhaustive descriptions of the skeletal material. I have also interpreted some of the information with the goal of presenting some information about the life histories of these two individuals. Generally, they both appear to be middle to late middle aged at death, and both exhibit arthritic changes and tooth loss, changes associated with age. Muscle attachment sites indicate that 1636 would have been engaged in more strenuous activity throughout life, and bone growth on the cranium is indicative of one or more pathological conditions. Both the metric and non-metric analyses show that there are size and shape differences between these two individuals and between them and other individuals in the collection. In general, these individuals provide an example of the complicated nature of skeletal dysplasias and also the difficulties that can arise in interpreting life histories in very pathological individuals when there is little context.

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Appendix A

Stature Estimates and Proportions

SpecimenID	Age	Sex	Race	Stature	Humerus/Femur	Femur/Tibia	Humerus/Radius	Distal Femur
TC 1636	**59**	**F**	**B**	**-**	**1.054474708**	**0.815873016**	**1.204444444**	**0.291828794**
TC 208	30	F	B	63	0.715231788	1.185863874	1.35	0.163355408
TC 815	32	F	B	65	0.675268817	1.204663212	1.281632653	0.172043011
TC 1555	41	F	B	62	0.702947846	1.263610315	1.280991736	0.160997732
TC 94R	35	F	B	60	0.729216152	1.185915493	1.306382979	0.182897862
TC 300R	**-**	**F**	**W**	**<55**	**0.708823529**	**1.365461847**	**1.43452381**	**0.205882353**
TC 289R	47	F	W	62	0.684085511	1.206303725	1.339534884	0.182897862
TC 1153	30	F	W	58	0.767857143	1.23659306	1.45410628	0.191326531
TC 1370	80	F	W	63	0.716589862	1.236467236	1.426605505	0.177419355
TC 1617	35	F	W	61	0.715990453	1.243323442	1.339285714	0.181384248
TC 49R	27	M	B	67	0.685300207	1.248062016	1.298039216	0.169772257
TC 235	30	M	B	68	0.695564516	1.164319249	1.296992481	0.177419355
TC 362	30	M	B	69	0.712598425	1.195294118	1.350746269	0.18503937
TC 522	30	M	B	64	0.717724289	1.187012987	1.256704981	0.188183807
TC 152	70	M	W	65	0.701793722	1.238888889	1.31512605	0.193693694
TC 434	41	M	W	70	0.71875	1.197007481	1.337209302	0.183333333
TC 645	28	M	W	70	0.699186992	1.165876777	1.303030303	0.180894309
TC 908	52	M	W	68	0.716981132	1.201511335	1.357142857	0.188679245