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DEMOGRAPHY, DIET, AND DISEASE IN THE TRANSITIONAL BASKETMAKER III/PUEBLO I PERIOD

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INTRODUCTION

This report summarizes information obtained from the human skeletal remains housed at Fort Lewis College, Durango, Colorado. This bioarchaeological resource represents remains retrieved from an area called Ridges Basin located southwest of Durango in southwestern Colorado. This particular skeletal collection is important for several reasons. It represents people living in a region that has been under-utilized in the interpretation of local and regional political-economic dynamics in the Four Corners region (Sebastian 1992). Furthermore, these burials are associated with a time period referred to by some as "transitional" Basketmaker III/Pueblo I (see Ware 1981:3-13). Thus, analysis of health and biological adaptation lends a critical dimension to understanding the impact of culture change as local groups shifted into different settlement patterns, experimented with new forms of architecture and design, and began sporadic attempts at agricultural intensification (Duke 1985).

Results from the analysis of 67 burials demonstrate that this population is quite distinctive in a number of ways. The patterning of traumatic lesions and associated pathologies suggests that some individuals were the recipients of violent actions that left lasting wounds. At least one child's and one adult female's remains show signs of peri-mortem breakage. Cranial and long bone fragments exhibit spiral fracturing and splintering consistent with violent death or alteration of the remains around the time of death.

Another intriguing feature of this collection is the relatively low prevalence of pathological lesions indicative of nutritional problems and infectious disease. That is, as a population, frequencies for many of the non-specific indicators of stress usually associated with undernutrition and/or high rates of transmissible infectious diseases are relatively low when compared with other Southwest groups. Frequencies of caries and other forms of dental disease at Ridges Basin are comparable to other agricultural groups. However, the dental data suggest that the diet was varied and not reliant exclusively upon maize.

This report provides a brief description of the methods used for data collection and the analytical techniques for processing the information. The major objectives of the research include the construction of demographic and health profiles. Baseline data on age, sex, pathologies, morphological measurements and other kinds of data are presented in a way that will contribute to the growing database on biological remains from the Ridges Basin area. Comparisons between the Ridges Basin population and other contemporaneous and later groups, particularly groups within the La Plata Valley, Chaco Canyon and Mesa Verde regions, are made whenever possible.

BACKGROUND ON THE RIDGES BASIN SKELETAL COLLECTION

The fifth to the eighth century marked much human activity in the Upper Animas Valley where Ridges Basin is located (Duke 1985). Indeed, throughout the Southwest during this time there is evidence of population growth along with expansion into new areas (Gumerman 1994). During this important transitional period there are only a handful of human remains associated with sites dated to this period. During this time there is the development of definable cultural traditions (Cordell 1984) and groups seemed to be rearranging themselves differently on the Southwest landscape.

Current models for understanding health in the prehistoric past place an emphasis on the benefits of non-sedentary, non-dense populations with mixed subsistence strategies (Cohen and Armelagos 1984). Because so many studies have documented the increase in pathologies with the adoption of agricultural and sedentary living, it is generally assumed that a pattern of robust living and good health follows a hunting and gathering lifestyle. This notion has been challenged by some authors (Larsen 1984) who show that complexities in environmental and cultural configurations in different areas can produce different patterns of health and disease.

In general, human skeletal remains represent a data base with the potential to unite physical anthropology and archaeology, and to provide empirical data on the effects of changes in settlement patterns and subsistence on health and community viability. It is unfortunate that the historical development of archaeology and physical anthropology was such that methods and theories evolved along separate and largely non-interactive trajectories.

This is particularly evident with the history of excavations in the Ridges Basin area. The Reverend Homer Root, Museum Curator at Fort Lewis College in Durango, conducted excavations in the Ridges Basin area in 1965 through 1969. In reading his elaborate portfolios and field journals from these excavations, it is abundantly clear that the burials were only of passing interest. The focus was on the associated grave goods. In 1966, while excavating a number of sites in Ridges Basin (5LP-245, 5LP-456 and 5LP-604) at least 40 burials were encountered by Root (Bonan 1985). Yet, these burials were likely never curated and notes from the field journals suggest that they were left in the spoil heaps. Root recovered the mortuary items from the burials for the Museum and this included such things as mounds of turquoise, quartz diamonds, pots, bowls, jars, ladles, vases and pitchers (Bonan 1985: 99). Even so, he retained a sense of awe for, but ultimately a lack of interest in, the human remains throughout the 4 years that he work in the area. Writing in his field journal (Volume 4 Page 21) he states ". . . I sometimes wonder if a prevailing influence lingers around a spot [where burials are]. . . of course, such childish sentiments have no part in the make-up of a professional archaeologist!" But unfortunately neither did the systematic recovery and analysis of these human remains.

Root is not alone in divorcing the human remains from the archaeological enterprise in the Southwest. Many archaeologists before and after him also failed to systematically recover and carefully analyze the human material (Martin 1994). In an attempt to bridge some of these gaps, "bioarchaeology" as a field of study has emerged lending a much needed integration of biological remains within an archaeological context.

Basketmaker II remains from Black Mesa, and Basketmaker III remains from Canyon de Chelly and the Prayer Rock District present to varying degrees pathologies which suggest that dietary inadequacies, infections, and childhood illness were problems for these people (El-Najjar et al. 1976; Martin et al. 1991). While the severity of the reported cases of infection and anemia are not as pronounced as those for later groups, it is important to note the presence of these pathologies on the small number of individuals recovered from this time period. Although the skeletal material that Root excavated is not available for study, he noted that the Basketmaker III/Pueblo I burials on Ridges Basin were tall and "long-boned," and that they looked generally quite robust. Without substantiation he states, however, that ". . . their knowledge was primitive. They must have suffered from ignorance pertaining to hygiene. . .problems of disposal, drainage, ventilation, cleanliness, [and] disease" (Root 1966:65). These ideas could be verified by conducting systematic studies on the human remains. The conflicting reports pronounce people living in Ridges Basin as fit and healthy on the one hand, and on the other hand, as long-suffering from disease.

By A.D. 800-850, decidedly larger groups began aggregating in the Southwest. Farther to the south in the Kayenta region, Black Mesa remains suggest an existence that was plagued by nutritional stress and other non-specific physiological disruptions. However, these disease rates represent a continuum of health problems present during Basketmaker III/PI times (Martin et al. 1991). Likewise, Chaco Canyon, Navajo Reservoir, and Dolores skeletal remains show involvement with iron deficiency anemia and infection. While not pronounced, these pathologies are present in sufficient numbers to suggest that at no time in the prehistoric Southwest were groups free from illness related to diet and infection. However, A.D. 800 represents the beginning of the trend in widespread population growth and population aggregation, and it is important to underscore that health problems existed prior to these cultural developments. Thus, the Ridges Basin data fill an important gap in the temporal and spatial analysis of diet, demography and disease.

The bioarchaeological resources at Fort Lewis College (Department of Anthropology) include 67 burials retrieved from Ridges Basin. However, twenty five years of differential excavation strategies, curation techniques, handling, storage, and analyses have rendered the collection incomplete. The remains originally came from approximately a dozen sites excavated over a number of years, and therefore it is not surprising that some of the material is no longer associated with identification numbers or provenience; likewise some of the material is now missing or in poor shape.

Biological anthropologists have long used health as one measure of human adaptability, particularly during stressful periods of rapid change or instability. Of recent interest are questions concerning how human populations respond to stress emanating from interacting cultural and biological spheres of influence. Disease states compromise *individual* responses but also can have an impact on activities at the *household* and *community* levels.

This collection represents a rich source of information on Pueblo communities during the Basketmaker III/Pueblo I period. Much of the emphasis in South`west bioarchaeology has been on the larger more populous communities occurring later during Pueblo II-III periods (A.D. 800-1300) (Stodder 1989; Martin 1994). Thus, analysis of health and disease can serve to link biological and social consequences of change and stress in human groups. The linking of biological and cultural processes is essential for dealing with the kinds of questions that archaeologists are interested in. For example, Minnis (1995) conducted a detailed analysis of Mimbres archaeological data in the context of examining food stress and the potential effect that it might have. Because the human remains from Mimbres have never been used to test the hypotheses generated, his theories regarding food stress remain untested. Likewise, recent work by Haas and Creamer (1994) examine the potential violent outcomes of increasing density and population size in the Southwest after A.D. 1100. While provocative and interesting, their thesis on the role of warfare and violence will be better grounded when data on physical trauma are integrated into a systematic and regional perspective on violence.

METHODOLOGY

The bioarchaeology community has long been concerned with the inconsistent and ultimately non-comparable ways that skeletal data are collected, analyzed, and reported. In an effort to encourage consistency and comparability, the Paleopathology Association published guidelines for the collection of data (Rose et al. 1991). These standards simply list the most commonly used metrical and observational analyses. In progress is a more thorough treatment of the topic with a team of bioarchaeologists (Buikstra et al. in press) working towards a computer software package for complete data collection from human skeletal remains. This project, referred to as the "Standard Osteological Database" will revolutionize the manner in which data are collected if researchers are properly trained in the methodology and if they have the time and resources to collect the information. In light of these developments, we designed a data collection sheet that approximated the Standard Osteological Database. Data on mortuary context (when available), the condition and status of the skeletal remains themselves, the location, severity and status of pathological and non-pathological lesions, metric and non-metric observations, and demographics are systematically recorded for each discrete individual. The data were analyzed using SPSSx, a statistical software package.

In general, our interest in reconstructing diet, demography, and disease focused our attention within the larger data base on the indicators of stress outlined in Table 1.1. These indicators provide maximum comparability with other published studies as well as conform to the standardization of skeletal and dental indicators of stress (Goodman et al. 1984a; Martin 1994). The following section briefly overviews the rational and methodology for the major categories of skeletal and dental data collected for the Ridges Basin skeletal material. It is not meant to be an exhaustive overview of the techniques, but rather an introduction to the topic and highlights of the areas where problems in reporting can occur. This overview of methods will allow future researchers to evaluate the data collection and decision-making processes that went into the interpretation and reporting of the skeletal and dental findings for Ridges Basin.

Assessment of Age and Sex

Assignment of age for all individuals and sex estimates for adult individuals is critical to any analysis that involves interpretations of demography, illness and death, and differential susceptibility of subgroups in the larger population. Age and sex form the basis for all subsequent analyses, and errors or biases at that level have an impact that multiplies as one begins to do more statistical manipulations of the data. Most analyses of death, diet, and disease involve the partitioning of individuals by age and sex according to a variety of observed conditions such as pathologies or metrics.

Skeletal populations are more readily diagnosed for age and sex than individuals. Errors are minimized by use of multiple methodologies. Accuracy of age and sex estimates is also greatly improved by understanding the range of variability of a population. Arranging individuals in order of increasing relative age or similarity in dimorphic features (referred to as seriation) is one way of minimizing errors. Whole skeletons within a given population can be used as references for partial skeletons. Differences in morbidity and mortality between males and females have important implications for the maintenance, longevity, and social organization of human groups. The correct determination of sex of skeletal remains is very important to the study of ancient behavior and population dynamics.

For the Ridges Basin study, establishment of age and sex provided the foundation upon which every single analysis relied. Using multiple methodologies and the most recently established criteria, the collection was independently aged by the two researchers (Martin and Goodman). When possible, all available specimens were seriated so that the range of variation for a given set of criteria could be best evaluated.

Because many of the Ridges Basin burials contained fragmented or partial skeletons, three major areas were evaluated to assure that some significant measures for assessment of sex could be obtained for almost all the adults. The areas include the pelvis, cranium, and femur. The measurements and observations from the pelvis include the angle of the sciatic notch, the presence or absence of the pre-auricular sulcus, the magnitude of the sub-pubic angle, the width of the medial aspect of the ischio-pubic ramus, and the ischio-pubic index. The cranium was measured and observed for the length of the mastoid process, the degree of prominence of the muscular ridges (temporal line, nuchal crest, supraorbital ridges and posterior root of the zygomatic process), the bicondylar breadth (width) of the mandible, the breadth of the ascending ramus of the mandible, and the palatal index. For the femur, the vertical diameter of the head and the bicondylar width were measured.

The Ridges Basin subadults were aged whenever possible by dental eruption and calcification and secondarily by long bone growth. No individuals were assigned ages based on epiphyseal union. All subadult dentitions were seriated with respect to crown and root development from youngest to oldest on the basis of dental development. This was accomplished by comparing the degree of calcification and, when appropriate, the sequence of eruption.

Age determination for Ridges Basin adults is based on several criteria. Techniques for aging using both the 10-phase system (Meindl et al. 1985a, 1985b; Todd 1920, 1921), and the 3-component system (Gilbert and McKern 1973; McKern and Stewart 1957) were employed. Also used was the method described by Lovejoy and co-workers (1985) on the morphological changes in the auricular surface, and Phenice (1969) on the ventral arc. Ectocranial suture closure was observed using the methodology of Meindl and Lovejoy (1985) when pelves were not available. Using the methods of Miles (1963, 1978) and standards in White (1991), subadult dentitions in the six-to-eighteen age range were used to determine a functional rate of wear for each of the three molars. The rate of wear determined from these individuals was then used to estimate age of adults by means of seriation and reference to those of "known" ages. An estimated developmental age was arrived at for most of the adults based on confirmation of results using more than one criteria for age. Midpoint in the estimated age range was established when possible based on all available criteria and on comparison of individuals (Tables 1.2-1.5).

Paleopathology

Through a systematic approach to paleopathology information is gained in several areas. First, we define the demographic pattern, geographic distribution, and chronological limits of disease at Ridges Basin. Second, we use this information to understand group biological and cultural adaptation in a regional perspective. Finally, we provide an explanation of the processes that underlie the disease patterns seen in the archaeological record. In this way, human skeletal analysis and anthropological inquiry are united.

Because differential diagnosis is often difficult and requires multiple confirmations, the collection of data on pathological lesions was based on a thorough description of the condition. This method, pioneered by Palkovich (1980), Magennis (1986) and Powell (1988) relies on a careful set of descriptions based on the type of pathological lesions present. Because bone has a limited response to any kind of physiological disruption, it can be broken down into four basic categories: osteoclastic or resorptive lesions, osteoblastic or proliferative lesions, lesions related to trauma, and a miscellaneous category rarely used when the other three do not quite fit the observed condition. After scoring the bone lesion within these large descriptive categories, a further assessment can be made. For example, if there was an osteoclastic or resorptive lesion, it can be further described by choosing among the following: superficial cortex only, subcortical involvement, granular walled, stellate, porotic hyperostosis, osteoporosis or osteopenia, and a miscellaneous category for all other descriptors. If there was an osteoblastic or proliferative lesion, it can be further described in the following manner: cortical pitting/striations only, periostitis with subperiosteal apposition, osteomyelitis with destruction of the cortex, a combination of the above, osteitis and increase in bone density, osteoma/benign tumor, osteophytosis, and a miscellaneous category. Location and status of the lesion is likewise recorded using a series of prompted responses.

What follows is a very brief overview of the rationale for how information was collected for individual skeletons from Ridges Basin. A summary of morbidity and mortality indicators is provided in Tables 1.2-1.5). These are also the pathological conditions most frequently cited in publications on patterns of health and disease for other archaeological populations living in adjacent areas such as Mesa Verde (Bennett 1975; El-Najjar et al. 1975; 1976; Stodder 1987) and Chaco Canyon (Palkovich 1985; Akins 1986).

Porotic Hyperostosis

We are interested in answering a number of questions concerning the nutritional status of the Ridges Basin populations. How frequently did the Ridges Basin population suffer from nutritional deficiencies? Is there a difference in the nutritional status of the Ridges Basin population through time? Are particular segments of the population more at risk than others?

A major breakthrough in analyzing nutritional disease resulted from a movement away from using single indicators of stress to an approach that considers multiple indicators, which are systematically analyzed to provide an understanding of nutritional disease stress. There are now a number of lesions, such as porotic hyperostosis, defects in enamel development, growth retardation, and poor maintenance of bone, that can provide documentation of general nutritional adequacy.

Of these indicators of nutritional stress, porotic hyperostosis (resulting from anemia) is among the best-studied indicators for archaeological populations. Anemias can potentially affect any bone of the skeleton that is involved in the production of red blood cells. The extent of the involvement of postcranial as well as cranial bones usually indicates how severe an anemia is and whether it is associated with genetic abnormalities of hemoglobin or with nutritionally induced anemia (Stuart-Macadam 1985; 1987).

Porotic hyperostosis is a descriptive term for lesions on the cranium and the roof of the eye orbits. These lesions are produced by bone marrow proliferation that is diagnostic of anemia. The lesion, as the name implies, has a very porous (coral-like) appearance that develops when diploe (the trabecular portion of the cranial bone that separates the inner and outer surfaces) expands. With the expansion of the diploe, the outer layer of bone becomes thinner and may eventually disappear, exposing the trabecular bone (diploe), which is quite porous.

The lesions of porotic hyperostosis typically involve thinning and destruction of the outer tables of the cranial vault, accompanied by thickening and exposure of the deeper diploic tissue. Porotic hyperostosis is usually symmetrically distributed and presents as a tight cluster of small porous opening that are visible to the naked eye. All such occurrences were recorded for the Ridges Basin series.

Nonspecific Infection

Although it is true that only a limited number of disease conditions leave diagnostic markers on the skeletal system, it is fortunate for skeletal biologists that some common and highly prevalent microorganisms that cause illness do initiate changes in the morphology of bone tissue. Lesions that affect bone are primarily from chronic conditions. Acute or epidemic conditions do not usually affect the skeleton because microbial attack is swift and death occurs soon after (Ortner and Putschar 1981).

The two types of infection (chronic and acute) provide different kinds of information concerning past populations. Epidemics reveal information on population responses to relatively short-term crises and high death rates. Chronic (and typically nonlethal) conditions are important to track at the community level because it may be these illnesses that shed the most light on everyday occurrences of nutritional adequacy, diet, the level of transmissible diseases, and the state of waste disposal and hygiene. In other words, low-level, lingering, but nonlethal bouts of infection can reveal something about life-style and group living that the more virulent and epidemic infections cannot.

Most examples of infectious disease found on skeletal remains are non-specific in nature. That is, the lesions can be caused by a number of pathological conditions, and differential diagnosis concerning exact etiology is often difficult. The most common causes of infectious disease are microorganisms such as staphylococcus and streptococcus, making up nearly 90% of cases (Ortner and Putschar 1981:106).

The general inflammatory response always begins as a vascular phenomenon (Ortner and Putschar 1981:104). Dilated capillary walls burst and cells normally retained in the circulatory system are released. These cells, which include albumins, globulins, and fibrogen along with leukocytes, travel to the site where there is bacteria. Leukocytes can engulf and destroy bacteria, or the bacteria, if numerous or virulent, can disintegrate the leukocytes and continue to increase in number. Pus is produced when leukocytes (along with proteins and fibrin) are at the site of the bacterial invasion. The severity of the inflammatory response is tempered by the number of microorganisms left to multiply in the system.

There is some disagreement among paleopathologists as to the use of descriptive terms and diagnostic criteria. For example, osteomyelitis results from the introduction of pyogenic infection (pus-producing--not all infections are), usually via the bloodstream, and the skeletal response involves the periosteum, cortex, and medullary cavity of the bone. It results from a systemic bacterial invasion (usually from bacteria such as staphylococcus or streptococcus) of the body. Some paleopathologists have advocated using general descriptive categories for classification of the skeletal changes (Palkovich 1980; Larsen 1987; Powell 1988; Martin et al. 1991). Referred to as nonspecific infectious lesions, the skeletal lesions are categorized as periosteal reactions because most of the skeletal response takes place on the outer periosteal surface of bone.

The Ridges Basin skeletal remains were analyzed using descriptions of pathological alterations that characterize the skeletal condition of periosteal reactions. No attempt was made to diagnose specific etiological categories of infections, nor were distinctions made among possible causes. The general non-diagnostic term of periosteal reactions is used throughout. Data collection from the Ridges Basin skeletons consisted of gross analyses, aided by low magnification microscopy, of all bones available. The protocol for data collection was patterned after several published accounts (Goodman et al. 1984b; Mensforth et al. 1978; Palkovich 1980; Martin et al. 1991). Each bone was scored for the severity in expression of the periosteal pitting (always an osteoblastic response), the location of the pitting, and the amount of remodeling, or healing, that occurred prior to death. For assignment of severity (trace/slight, moderate, or severe) we looked for (a) the extent of the involvement, (b) the nature of the tissue destruction, and (c) the overall amount of destruction. Location of the lesion was specific to the bone; for flat cranial and pelvic bones, location was recorded for quadrants such as upper left, and for long bones, location was recorded with respect to proximal, distal, and mid-shaft locations. Additionally, cranial bones were analyzed for periosteal reactions endocranially, when possible.

The amount of healing was assigned as no healing (or active and unremodeled), some healing (remodeling in progress), and totally healed (with only remnant pitting or scars from the previous insult. Unremodeled lesions generally display a very fibrous and vascularized irregular new layer of bone. Remodeled lesions show resorption and redistribution of new bone as it becomes incorporated into the normal cortex. It appears as dense, smooth bone with some minor but patterned irregularities. Periosteal reactions due to infectious diseases are usually systemic in nature, affecting multiple long bones, bilaterally in most cases.

When scoring a femur for periosteal reactions, as an example, other long bones were observed in concert to see if they were involved as well. If there were other bones involved, the femur was scored as having a periosteal reaction. If it seemed to be an isolated event, it was considered to be a localized traumatic response and was scored as a trauma. Ortner and Putschar (1981) point out that trauma-induced periosteal reactions tend to be small, localized, and nondestructive. Systemic infectious diseases tend to be generalized and destructive, and they often affect multiple bones. Thus, the label of periosteal reaction was reserved to confer the status of systemic infectious disease response.

Osteoarthritis

Osteoarthritis is among the oldest and most commonly known diseases afflicting humans. Measuring the amount of arthritic involvement with skeletal remains is sometimes difficult because of the potentially large number of areas to be assessed (each vertebra and all joint systems) and the range of variation in bony response among individuals. While many factors may contribute to the breakdown of skeletal tissue, the primary cause of osteoarthritis is related to biomechanical wear and tear and functional stress (Jurmain 1977; Ortner and Putschar 1981). Biomechanical stress is most apparent at the articular surfaces of long bone joint systems and is referred to as degenerative joint disease (DJD). The patterning of DJD has been linked to behavioral factors and individuals who habitually engage in activities which put strain on the joint system are more likely to demonstrate a breakdown in bone (Merbs 1983). There also may be a relationship between DJD and other health problems. For example, a study correlating the incidence of DJD and periosteal reactions (infection) was undertaken for the Dickson Mound population (Martin et al. 1979).

Individuals with multiple joint involvement demonstrated statistically higher percentage of periosteal reactions. Both infectious lesions and DJD appear to be a function of age in this population. Furthermore, females demonstrated higher frequencies than age-matched males of DJD in the shoulder and elbows suggesting that subsistence activities such as corn grinding may have been women's work.

Degenerative joint disease is generally defined by changes in the articular surface areas of joint systems. Following the exposure of subchondral bone, the articular surface regions become pitted, with marginal lipping and erosion; eventually eburnation takes place. Eburnation is the formation of a very hard callus on bone surfaces which are rubbing together without being cushioned by lubricating fluids. DJD is not an inflammatory disease, but develops on the basis of aging changes and breakdown of the cartilage and lubricating system. The condition is slowly progressive, but is not found to occur in all older adults in the same form. Thus, the condition probably is the accumulation of years of alterations of the articular cartilage and breakdown of the joint, and occurs with extreme variability across individuals. Lifestyle and activity play an important role in either buffering an individual from arthritis or enhancing the chance that the condition will appear. The weight-bearing joints such as the lower back, hip, and knees and those exposed to chronic trauma such as the shoulder and elbow are most frequently affected (Jurmain 1977). The pattern, distribution, severity and onset by age class and sex in adults can be used to interpret the role of cultural activity, as well in the overall understanding of quality of life for individuals within the community.

Trauma

Traumatic lesions encompass a broad range of clinical classifications that include fractures, crushing injuries, wounds caused by weapons and other devices, dislocations, and an assortment of degenerative problems such as exostoses, osteochondritis dissecans and spondylolysis (Steinbock 1976; Ortner and Putschar 1981; Merbs 1989). These types of injury are primarily caused by physical force or by contact with sharp or blunt objects. The cause of traumatic lesions can often be determined by analyzing the intensity and direction of the force. Interpretations concerning trauma are generally more direct than other kinds of pathologies, especially if the age, sex, and health status of the individuals are known. For example, if the traumatic lesion occurs with periosteal reaction and infectious inflammation, a severe condition which originally involved the soft tissue, as well as the bone, is implied. Simple fractures that do not break through the soft tissue and skin rarely become infected (Steinbock 1976). Also, the degree to which a trauma has healed provides a clue to the relationship between the event and the possibly contribution of the trauma to morbidity and mortality.

Fractures in long bones, ribs, and vertebrae are the most frequently reported of the traumatic lesions in the paleopathology literature (Merbs 1989) and the most easily assessed. Fractures can be classified into a number of categories ranging from micro stress fractures to greenstick breaks to comminuted and complete breaks. However, the response of bone to any kind of fracture is the same. There is immediate vascularization and new bone forms within a few days after the break occurs. Calcium salts are released from dead bone fragments and also from the living bone and are used in calcifying the callous matrix which forms a binding and connecting sheath around the two fractured ends. Within two weeks, calcification is underway and the internal remodeling and reorganization of the bone callus begins. The healing process can last for months or years, depending on the age and health of the individual and the severity of the break (Ortner and Putschar 1981). Even a poorly aligned or unaligned bone will eventually mend itself if infection does not interfere with the healing process. The process occurs much more quickly in children than in adults. Union of two bone ends can be complete in four to sex weeks in children, while in adults the process can take four or five months (Merbs 1989).

Depression fractures occur most frequently on crania and have been reported for many specimens in the archaeological record (Ortner and Putschar 1981). Merbs (1989) defines a depression fracture as one produced by a force applied to just one side of a bone whereas compression fractures are produced when there is force from two sides; however, these distinctions can be difficult to make in archaeological specimens and shallow holes in the cranium are often referred to as depression fractures. Depression fractures usually result from a blow to the head by a blunt object. On the cranium, this results in a depression in the outer bony table and if the skin is broken, there will be some infectious response as well. The pathophysiological responses are similar in cranial fractures: there is a coagulation of blood at the site with resultant formation of new bone at the fracture site. After the site has completely remodeled and healed, there will usually remain a telltale depression in the cranium at the original site usually remains.

In archaeological specimens, fractures and traumatic lesions in the process of healing or with complete healing are fairly straightforward in diagnosis. However, when traumatic events occur around the time of death, it can be difficult to distinguish the perimortem bone damage from postmortem changes. Although numerous researchers have attempted to isolate the differences between perimortem and postmortem breaks, without other information regarding the context of the burial and the nature of the death, it is almost impossible to make firm diagnostic interpretations (White 1992). For example, although bone crushed from the blow of a blunt object will shatter bone differently when it is fresh versus later when it is dry, recovery of all of the pieces of bone is necessary for distinguishing the timing of the breaks (Mann and Murphy 1990). The amount of bone beveling and the type of fracturing (spiral versus straight) has been used an important indicator of the timing of the traumatic event; however, in reality these are related to plasticity of the bone at the time of the event. Another example of problematic diagnosis is that the nonunion of a fractured end of a long bone could be interpreted upon recovery as an amputation if the distal end is not also recovered.

Bones that are in the process of healing need to be cautiously interpreted. The rate of repair and remodeling is modified by age, type of fracture, where the fracture occurs, degree of vascularization, amount of motion between the broken ends, and presence of infection (Steinbock 1976). Infection at the site of the bone fracture can seriously hamper repair, and the determination of the timing of the fracture on archaeological specimens is rarely possible without determining the nature of the healing process in conjunction with a wide number of variables having to do with the individual.

Careful observation of the entire skeleton of individuals with trauma can aid in the understanding of not only the timing of the event, but also related health problems. For example, a healed fractured femoral neck may contribute significantly to osteoporosis and osteoarthritis in adjacent bones (Merbs 1989). Asymmetry in body proportions may occur when unaligned bones heal making compensatory biomechanical changes necessary. These kinds of secondary changes are important to note because they could contribute significantly to our understanding of the quality of life and changes in health that may accompany a traumatic lesion.

The extent to which fractures disable and deform individuals can sometimes be assessed, and this information can be very important in understanding community health dynamics. Adults crippled by unaligned fractures could be less productive in subsistence activities. Furthermore, lifelong accumulated adjustments in the form of limping and inefficient gait would also enhance osteoarthritic changes in joints and other health problems. The medical aspects of trauma in precontact groups is largely speculative, although Merbs (1989) has reviewed a number of cases where "bonesetting" was clearly a skill that some groups possessed.

Specific types of trauma can provide a direct inference about behavioral patterns. Certain activities predispose individuals to certain types of accidental or intentional trauma. Moreover, various forms of interpersonal violence (warfare, scalping, mutilation, lacerations, cannibalism) and of surgical intervention (trephination, amputation) can sometimes be specifically identified (Merbs 1989; White 1992). Fractures of the forearm (radius and ulna) can reveal information about the activities of the group. A common fracture seen in many archaeological specimens is at the distal end where the wrist is located and these are generally referred to a Colles fractures. They result when an individual who is falling extends the arms in order to break or soften the fall. Fractures that occur farther up along the forearm may result from the raising of the arm in front of the face to ward off a blow (these are called parry fractures).

The patterning of the trauma within a population can be very enlightening regarding environments conducive to accidents, as well as inter- and intra-group strife. The occurrence of multiple injuries, injuries from artifacts and weapons, and the demographic pattern by age and sex can provide insights into the use of force or violence in a society or the potential problems in lifestyle and subsistence activities that lead to accidents.

Dental Wear, Caries, and Premortem Loss

Teeth were categorized according to the following conditions: (1) present, (2) lost premortem, (3) lost postmortem, (4) unerupted, (5) agenesized (congenital absence), and (6) unknown (due to missing alveolar bone). The distinction between premortem and postmortem loss was made on the basis of presence of bone remodeling in the root socket. Although this is a standard technique, it may slightly under-enumerate the number of teeth lost premortem. For the purposes of this analysis, the most important category involves the frequency of premortem loss versus the frequency of combined present teeth and those lost after death.

Dental pathologies for the following conditions are summarized: dental wear (attrition), carious lesions (cavities), and premortem tooth loss. Dental wear is a general term referring to the loss of the occlusal or chewing surface of teeth and also to the interproximal surface between teeth. Wear may be divided into two components, dental attrition, due to direct tooth-on-tooth contact, and dental abrasion, due to the introduction of foreign matter (Scott and Turner 1988). Strictly speaking, dental wear is not a pathological condition. Rather, as much as any condition that is tracked, it is best considered a normal consequence of chewing. As such, it is a highly age-related phenomenon. Indeed, one of the primary reasons that skeletal biologists analyze dental wear is as a technique for aging individuals (Lovejoy 1985).

The indicators of stress reviewed here are not an exhaustive survey of every available type of analysis. It is a selection that maximizes information on demography and disease and allows future researchers to rapidly evaluate what is presented here for comparative purposes. Indeed, each indicator of stress could form the basis of a major comparative study but that is not the purpose of this report. We have been selective about what we focus on but we also recognize that working within NAGPRA guidelines means that there may be not be other chances for data collection from this skeletal series in the future. The data collected from Ridges Basin material has been archived at Northern Arizona University and Hampshire College and are available upon request. Thus, the information coded on the forms may form the basis of future studies and in this respect are relatively thorough and as systematic as we could be given the combined objective and subjective nature of skeletal analysis. What we do focus on in this report is demography, indicators of stress, dietary reconstruction, a synthesis of the findings, and conclusions and suggestions for future research.

DEMOGRAPHIC FEATURES OF THE RIDGES BASIN SKELETAL POPULATION

Mortality data for skeletal populations derive from assessment of individual ages at death. Traditional presentations of mortality data involve the use of survival (from one age to another) to graph survivorship curves. Life expectancy as a function of survival has also been used in many studies. Angel (1969) has argued against mathematical modeling more complex than relatively simple statistical procedures. For example, he suggests that calculations such as proportions of infants and children to adults or comparison of survivorship curves are all that is required for demographic analysis of precontact populations. The Ridges Basin skeletal collection is not sufficiently large enough nor representative to do life table analysis on. Descriptive frequencies are used instead to outline the basic demographic features of the collection.

The demographic analyses of the Ridges Basin collection suggest an non-representative population with under-enumeration of both young children and older adults (Table 1.6). Of the 67 burials, there are 18 subadults (2 could not be assigned an age and are not represented in the table) and 49 adults. Of the adults that could be assigned an age, there are 17 males and 15 females.

Brothwell (1981) reports that the proportion of infants under the age of 1 relative to the total number of children under the age of 19.9 should fall between 25% and 75% of the total sample under the age of 20. If proportional frequencies fall within this range, the population is most likely unbiased relative to the living population. The Ridges Basin sample of infants is quite small and the frequency therefore is only 5.9% (Table 1.7). The subadult portion of the population (between the ages of birth and 19.9) is 25.2% which is on the extreme low side of Brothwell's range for a normally distributed non-industrialized population.

Why might there be fewer infants in this sample? Beaglehole and Beaglehole (1935) and Dennis (1940) suggest that historic Hopi infants that are stillborn or those who die before 20 days are not yet considered members of the community and are buried away from the usual places, and this may explain why so few infants are in midden areas or domestic structures at Ridges Basin. Poor preservation and taphonomic processes may also explain a lack of infants at Ridges Basin, but the extent to which they are under-enumerated cannot ever be fully explained.

The other problem is the clustering of adults in the younger age categories (Table 1.6). The greatest majority of adults occur in the age categories 20 to 35, with very few individuals in the 45 and older age categories. It is difficult to speculate on why there are so few elderly represented, but given the biases introduced into the excavation and retrieval of burials, we are at least able to clarify the areas most problematic for analysis.

HEALTH PROFILE FOR THE RIDGES BASIN COMMUNITIES

As with demographic variables, the health status of southwestern precontact societies has long been recognized as a fundamental aspect of understanding and interpreting the past. From Mathews and colleagues (1893), Hrdlička (1908) and Hooton (1930) we see early attempts to characterize health of the ancient Pueblo Indians through their skeletal remains. Readers of this early literature are simultaneously impressed that these researchers write with such descriptive detail, but also frustrated by their ability to link their observations in systematic ways with other facets of archaeological reconstruction. The impressions recorded about the biological characteristics of ancient Pueblo people were often a blend of subjective and personal ideas regarding how they lived and why they died (e.g., Colton 1960; Cummings 1940; 1953; Fewkes 1904; Morris 1939; Root 1966). Most of the discussions are cast in either a rosy glow about the noble ancient ones who have survived the slings and arrows of outrageous misfortune, or there is a tone that implies that these people were unenlightened and backward in their knowledge of sanitation and health care. The focus of many of the reports on health and disease continue to be a tabulation of medical anomalies and pathologies for individual skeletons (e.g., Bennet 1966; 1973; 1975; Berry 1983; Hrdlička 1935; Miles 1966; 1975; Nickens 1975; Reed 1946; 1965).

It is fortunate for us that common and highly prevalent microorganisms that cause illness do initiate changes in the morphology of bone tissue, such as anemia, staph and strep infections, respiratory ailments, gastrointestinal problems, and dysentery. These are precisely the conditions that people today living in marginalized and Third World settings die from in high frequencies (Allen 1984; Dyson 1984; Leatherman 1987). In general, acute or epidemic conditions do not leave evidence on bone (Ortner and Putschar 1981). Lesions that do affect bone are primarily from chronic conditions. We argue that it is the endemic day-to-day stresses that are important to document, for these reveal more about the environmental and cultural factors that people must deal with on a regular basis.

Patterns of death and disease are not random occurrences. They are intimately linked to every facet of lifestyle from diet and climate to occupation, social structure and religion (Wells 1964:87). Although death is the ultimate indicator of maladaptation, its timing and patterning within populations reveals a variety of challenges in the physical and social environment. Some have criticized the ability of skeletal biologists to make useful inferences from paleodemographic and paleopathological data (Wood et al. 1992), but Goodman (1993) has addressed and rebutted many of these. He points out that skeletal biologists focus on multiple indicators of stress and that in combination with an understanding of the ecological and cultural context, health profiles can be constructed that approach biological realities.

The principal intent of this study is to establish parameters of health of the people living in the Ridges Basin. The small size and biased nature of the sample limits an extensive statistical study. In this study we have been able to confirm good health among some subgroups within the population, and relatively poor health for others. Also, we have begun to locate places where definite signs of biological afflictions may be linked to cultural practices. Categories of skeletal manifestations of disease are discussed with an eye towards establishing patterns within the population, and with noting any trends in health across age and sex groups at Ridges Basin.

Porotic Hyperostosis

The results of the analysis presented here suggest that iron deficiency anemia and its resultant health complications were ubiquitous but not a severe health problem. For the subadult population as a whole (aged newborn through fifteen or so), one-third (33.3%) of the individuals demonstrate cranial involvement (refer to Table 1.2). Of the three subadults with lesions, all were slight in expression and in the process of healing (remodeling). None of the children from Ridges Basin had lesions which could be characterized as severe in expression. The cases of porotic hyperostosis are distributed throughout the age categories suggesting some protection to the most vulnerable groups.

In the adult portion of the sample (Tables 1.3 and 1.4), anemia appears to have been an equal liability for both males and females suggesting that it is a function of shared dietary and lifestyle activities. For the eight females that could be scored for porotic hyperostosis, two (25.0%) demonstrated cases that were moderate in expression with signs of healing. Of the eleven that could be scored, four (36.6%) showed lesions, and most were slight in expression with all cases demonstrating healing at the time of death except for one case of slight and active lesions. Of the eighteen adults that could not be assigned age and/or sex, 57.1% demonstrate porotic hyperostosis. Thus for the total adult population, 32.1% were affected by an anemic condition.

Comparing these frequencies with comparable data from other Southwest groups suggests that Ridges Basin is among the lower frequencies reported for groups that are later in time (Table 1.8). Comparison of childhood frequencies of porotic hyperostosis demonstrate that the Ridges Basin sample is among the lowest. Although these comparisons suggest that Ridges Basin individuals experienced less of the side-effects of iron deficiency anemia than did their later counterparts, it is difficult to interpret these data directly. There have been a number attempts to summarize all published accounts of porotic hyperostosis for Southwest archaeological populations, the most notable being El-Najjar and colleagues (1976), Walker (1985) and Stodder (1987; 1989). Problems exist in the manner that data are reported; often frequencies are given for cases of porotic hyperostosis located in the orbital area (referred to as cribra orbitalia) separate from cases of porotic hyperostosis located on the cranial vault. It is also problematic that some of the earliest research by El-Najjar and colleagues failed to elucidate their exact methodology for the collection of porotic hyperostosis data. Research into the etiology of the lesion over the last 10 years have undoubtedly affected how skeletal biologists collect data on porotic hyperostosis.

Taking these problems of comparison into mind, it does appear that Ridges Basin demonstrates lower frequencies than at other sites. Ridges Basin frequencies are lower than those reported for other sites. For example, the Black

Mesa sample (PI-II) had an overall frequency of 87%, and Canyon de Chelly (PII-III) shows a frequency of 55.1% (Walker 1985:143). For sites later in time (San Cristobal and Hawikku, PIV) Stodder (1990:223) reports frequencies of 87% and 74%, respectively.

Interpreting the Ridges Basin data on porotic hyperostosis involves a simultaneous understanding of a number of factors. Early interpretations of porotic hyperostosis linked it exclusively to an iron-poor diet (e.g., El-Najjar et al. 1975; 1976) but it is now assumed that diet per se may play a less prominent role in the expression of anemia in a population. While it is important to note the iron content of foods likely to have been eaten, it is equally important to examine how other micronutrients and culinary practices interact with iron in the diet. Maize is itself a rather poor source of iron, and it is the phytic acid in it that is primarily responsible for inhibiting iron absorption. Phytates also however is known to inhibit the absorption of zinc, whose interactions with iron are important (Sandstrom et al. 1987). Phytic acid comprises 1-3% of all nuts, cereals, legumes and oil seeds. Because of its chemical structure, it can form chelates with minerals such as calcium and iron. Hurrel (1992) found that reducing phytase levels to a specific concentration can increase iron absorption up to five-fold. Different varieties of corn have variable concentration of phytase. Hopi corn ranges from 0.4% to 2.2% and Kuhnlein and colleagues (1979) found that the practice of adding culinary ash to the meal resulted in a calcium-phytase complex that permitted greater iron availability. Maize prepared into nixtamal (or masa) for preparation of tortillas or other maize foods by being heated in boiling water to which lime has been added and left overnight to soak increases calcium content by over 2000% (Kuhnlein et al. 1979). Other kinds of ash are also beneficial. Mesquite ash can increase calcium content eleven-fold, and juniper branches, corn cobs and other materials added as culinary ash could likewise increase levels of calcium, iron, copper, zinc, and strontium to meal prepared from maize. Vitamin C, needed to increase iron absorption, is present in significant amounts in prickly-pear and cholla, as well as squash, pumpkin and amaranth.

Duke (1985) summarizes the Ridges Basin ecology as a semi-arid desert which experiences great variability in climate. The soil is largely a silt clay loam that is quite amenable to agriculture, particularly if irrigated and if erosion does not occur. The paleoenvironment at Ridges Basin would likewise have had deer, rabbits and a great number of other small mammals. Native grasses such as goosefoot and pigweed would likewise have grown in great abundance.

The presence of iron deficiency anemia as confirmed by the presence of porotic hyperostosis suggests that iron deficiency anemia was endemic to the Ridges Basin communities, but more likely it contributed to sporadic or low-level morbidity and quality of life more so than to mortality. Understanding the source of the anemia however is more difficult. The likely preparation of corn into nixtamal and the addition of any kind of ash served to make the iron bioavailable so the signs of iron deficiency anemia seen in the Ridges Basin sample may be factors other than dietary inadequacy. Instead of viewing a maize dependent diet as deficient in nutrients and a contributor to poor health, it can be seen as a storable and dependable source of carbohydrate, lipids, and protein that was probably adequate for most segments of the population. Waste management and proximity to people with transmissible infectious diseases may account for more of the anemia than did the diet.

Regardless of its root cause, iron deficiency in even slight to moderate rates should be considered as a red flag. Iron deficiency anemia is the single most common nutritional deficiency in the world with 25% of all infants and 66% of children being affected in developing nations today (Wardlaw 1993:458-485). The symptoms of iron deficiency anemia (which do not preserve in the archaeological record) are pale skin, brittle nails, fatigue, apathy, poor temperature regulation and loss of appetite. Learning ability, work performance and immune status can be significantly compromised by poor iron stores. Thus, although we feel that the frequencies at Ridges Basin are low to moderate by Southwest standards, we do not want to overlook or underemphasize that in any manifestation, it suggests the potential to affect the most vulnerable of the group, in this case children. Combined with other problems, like staph and strep, the synergistic effect could be deadly.

Systemic Infections

For the subadult portion of the Ridges Basin population, two out of eleven (18.1%) possible cases demonstrated lesions indicative of generalized non-specific infection (Table 1.2). Of children with periosteal reactions of the long bones, both cases were moderate in expression and demonstrated signs of healing at the time of death. It is difficult to assess the age of onset of infectious disease in this subgroup because of missing information in the younger age categories, but both cases of periosteal reaction are in children aged 1.5 to 3.

For the adult population, the overall rate of periosteal reactions is 12.0% with cases being either slight or moderate, with some cases healing and one case that was active at the time of death (Tables 1.3-1.5). By sex, there is only one male (11.1%) that demonstrates these lesions. For females there are two individuals (15.3%) with lesions and these are generally moderate in expression.

Comparison of the Ridges Basin sample as a whole with select contemporaneous samples indicates that the frequencies are similar to other burial populations from the Four Corners area (Table 1.9). Ridges Basin is similar to the frequencies for Chaco Canyon small sites, Pueblo Bonito and the La Plata Valley.

Adult Stature

Studies of adult morphology provide an interesting contrast in terms of limitations and potentials relative to studies of subadults. Studies of adults are not constrained to a great degree by problems of assignment of age and sex, nor are small sample sizes as frequently a limiting factor. As in studies of adult anthropometry of living populations, the drawbacks to studies in prehistory revolve around the loss of sensitivity for clarifying underlying processes affecting growth and ultimate size at adulthood. The loss of the most stressed segment of the population due to death before adulthood, coupled with the ability to catch up in growth, renders adult morphology potentially less sensitive to environmental variation when compared to subadult growth and development.

The mean stature for males and females, as computed from Genoves's (1967) formula for the femur approximates 5'5" or 165.6 cm (n=5) and 5'0" or 152.4 cm (n=5), respectively (Table 1.10). These data suggest that Ridges Basin adults, when compared with other Southwest contemporaries, were not experiencing major problems in attainment of adult stature. The degree of sexual dimorphism is estimated by the ratio of male to female stature for a number of southwest populations. In compiling this comparative chart, it was not always clear which long bone or formulae was used in the calculations, although it is assumed that the majority was based on femoral measurements and the formulas published by Genoves (1967). The amount of difference in stature across all groups ranges from between 4% and 7%. Hrdlička (1935) measured 105 men and 34 women in Pueblo villages along the Rio Grande and found that the men ranged between 4'10" and 5'9", and females ranged between 4'8" and 5'3". Cummings (1940:93) reported a male from the Kinishba site who measured 6'2" ". . .from the top of his head to the bottom of his heel". Morris (1924) also reported a stature of over 6' for a male buried at Aztec Ruin.

Adult stature at Ridges Basin indicates that individuals surviving to adulthood were not seriously growth-stunted (Stinson 1985). Nickens (1976) has shown that sexual dimorphism in height decreases in Mesoamerican groups as a response to food shortage and malnutrition. None of these factors appears to be operating at Ridges Basin.

From both metrical analysis and observations made in the laboratory, both males and females from Ridges Basin exhibit quite robust skeletons, although there were clearly exceptions to this with a few adults who seemed quite gracile. The data suggest that life at Ridges Basin may have demanded a high degree of physical labor, but preservational quality and sample size prohibit more detailed analysis.

Gray and Wolfe (1980) computed the mean stature of males and females based on a broad survey of 216 societies. Interestingly, their mean heights for males and females, 163.5 cm and 151.9 cm respectively, are quite similar to the mean heights for the Ridges Basin sample. Both the achieved heights and the relative difference in heights between males and females for Ridges Basin are similar to those of many other precolonial and historic groups living in traditional and marginal societies. The data suggest at least mild-to-moderate-degree nutritional stress, as is likely to have been experienced by most of the groups sampled by Gray and Wolfe (1980) given their cultural and environmental contexts.

Linear Enamel Hypoplasias and Other Developmental Enamel Defects

Linear enamel hypoplasias (LEH), a class of developmental defects of enamel (DDE), are among the most commonly used osteological indicators of nutrition and health status. LEHs are easily observed, indelible once formed, time specific, and relatively unambiguously linked to past periods of physiological stress (Goodman and Rose, 1990; 1991). The prevalence of these defects is outlined below. Other developmental defects of enamel, specifically enamel hypocalfications and hypoplastic pits, were also seen on Ridges Basin dentitions. The etiology of these defects is less clearly understood (Goodman and Rose, 1990).

Deciduous Dentition. Of the three well preserved Ridges Basin deciduous dentitions, one showed evidence of developmental disturbance in the form of a hypocalcification. No case of linear enamel hypoplasia was identified.

In comparison, twenty-three percent of the Black Mesa (PII) subadults with anterior teeth exhibited a hypoplasia (Martin et al. 1991). The Black Mesa deciduous data are very similar to data presented for some contemporary populations living in marginal environments. Goodman and co-workers (1987) note hypoplasia rates of less than 14% for each deciduous anterior tooth in Mexican children, and Infante and Gillespie (1974) note rates of between 18% and 24% in Guatemalan children from three villages. Perhaps the most interesting comparison is with contemporary White Mountain Apache children for which Infante (1974) notes a prevalence rate of 19.4% which is quite similar to the late Pueblo Black Mesa rate of 23.4%

Relatively higher rates of deciduous hypoplasias have been reported for other archaeological populations. For example, Blakey and Armelagos (1985) found that 36% of 50 individuals from Dickson Mounds, Illinois (A.D. 950-1300) had deciduous hypoplasias. Recently Malville (1994) has reported very high rates (over 50% affected) in a small sample from Montezuma County, Colorado (the largest of these samples is Period II and III Yellow Jacket (5MT1/5MT3).

Given the very low sample size we can not provide an unambiguous explanation for the non-existence of deciduous enamel hypoplasias at Ridges Basin. However, the tentative evaluation is that it at the low end in comparison to most other Southwestern, precolonial and contemporary Third World populations.

The sample size is low and the some of the dentition are fragmentary. Thus all speculations are preliminary. As well, one needs to consider that highly stressed individuals could have died and been selected out and there is clear variation in minimal criteria for scoring a deciduous defect. However, these ambiguities aside, it is likely that the data reflect a comparatively low degree of in utero and neonatal physiological disruption.

Little can be concluded about the presence of a single deciduous tooth with an enamel opacity. This developmental defects may have a relationship to mineralization disturbance, but the mechanisms and epidemiology is poorly understood.

Permanent Dentitions. Enamel hypoplasias on permanent dentition from Ridges Basin varied tremendously in size and form. Most frequently found were mild linear defects, although a few severe defects were also found. In addition, a number of pit type defects and "pit patches" (Goodman et al. 1992), areas of disrupted enamel, were also found. Goodman and co-workers (1993) suggest that pit patches found at Black Mesa may indicate chronic, low level stress.

The overall prevalence of individuals with one or more hypoplastic defects is 54.8% (17/31). Although many individuals had multiple defects, the maximum number of clearly identified, separate episodes of stress/hypoplasia formation was three. In most cases (13 of 17) only one episode of stress could be determined, usually occurring between two and five years developmental age.

This peak is quite typical of other precontact populations and seems to be neither unusually advanced or delayed. For example, Stodder (1987) finds a peak at 2.5-3.0 for incisors and 4.0-5.0 for canines at Mesa Verde. Malville (1994) quite similarly detects a central incisor peak at around 2.5 years for Yellow Jacket Pueblo II and Pueblo III and upper and lower canine peaks between 3.5 and 5.0 years. Goodman and Armelagos (1984b) also find peaks between 2.0-2.5 for upper central incisors and 3.5-4.0 for canines for Dickson populations. The Black Mesa peaks are at 2.5-3.0 for upper central incisors and 4.0-4.5 for lower canines (Martin et al. 1991).

What explains a peak in LEH (stress) at 2.0 to 5.0 years at Ridges Basin? Factors to be considered include a low quality and quantity post-weaning diet, and increased susceptibility to infectious disease. Dennis (1940:99) states that the Hopi infant "is seldom weaned under one year of age and frequently is not weaned before two years". The data indicate that this subgroup is at higher risk than other age groups to morbidity and mortality. This is neither surprising nor highly revelatory except to add, in important ways, a more richly textured understanding of life at Ridges Basin for children.

The pattern of variation in defects within and among Ridges Basin teeth is somewhat unusual. In a detailed study of the pattern of enamel defects among teeth at Dickson Mounds. Goodman and Armelagos (1984b) found that the maxillary central incisor and mandibular canine were most often hypoplastic, and this pattern has been shown in a number of subsequent studies. Similarly, they showed that the earlier and middle developing portions of tooth crowns tended to be most susceptible to disruption. What is unusual at Ridges Basin is the somewhat more random occurrence of defects, with relatively high rates on anterior teeth and later developing portions of tooth crowns and relative low prevalences of defects compared to other Pueblo populations on anterior teeth and earlier developing portion of tooth crowns.

Lastly, comparisons and interpretation of the overall rate of defects on permanent teeth by individuals is somewhat difficult to interpret because of differential preservation and wear, and the differential susceptibility of tooth types to defect formation. Nonetheless, the low rate of 54.8% suggest that this was a population that received relatively good infant childhood nutrition and was relatively free from serious illnesses during infancy and childhood.

In terms of dental opacities, in comparison to other archaeological populations, a relatively high frequency of individuals had permanent tooth enamel opacities at Ridges Basin. In total 4 of 31 (12.9%) individuals had an enamel opacity on one or more permanent anterior teeth. In general, two patterns of opacity could be distinguished: either the opacity was in the form of diffuse mottling and affected all or nearly all tooth crowns or was localized to just one or tooth teeth.

As noted above, it is very difficult at this stage to do more than speculate on the etiology and meaning of the opacities. Opacities can result from may things such as high fluoride consumption and other difficulties in the incorporation of trace elements into growing enamel hydroxyapatite.

Discussion. The data on dental defects suggest the following. There is a relatively high frequency of opacities at Ridges Basin. The significance of these defects is yet to be determined. However, with some speculation we suggest that the high frequency of opacities may be related to high fluoride intake or an unusual pattern of intake of other trace minerals, which affected the calcification of enamel hydroxyapatite.

There is a very low frequency of LEH on permanent teeth, suggesting a low level of physiological perturbation during infancy and early childhood. These data are quite clear. However, they need to be considered in context of the pattern of mortality and in context of other indicators of general and specific morbidity. As with other archaeological and Southwestern populations, the greatest frequency of LEH is found around the ages of 2-5 years. A paucity of LEH in the first two years is likely related to the fact that individuals with severe stress likely died and were thus selected out. We suggest that this peak is "real" in that it reflects a heightened period of stress around this age.

Goodman and colleagues (1987) have studied the frequency and chronological distribution of enamel hypoplasias in Mexican children from five rural agricultural communities in the Solis Valley, Highland Mexico. These communities were selected for study because of the presence of endemic mild-to-moderate malnutrition (children at 60%-95% weight-for-age). The diet is based on tortillas and small amounts of meat and vegetables. They found one or more hypoplasias on 46.7% of 300 children examined. Among the unworn and completely erupted teeth, the highest prevalence was found on permanent teeth and especially the maxillary central incisor (44.4% were hypoplastic). Fourteen percent of the deciduous maxillary central incisors were hypoplastic. This prevalence is slightly less than but similar to the figures of Infante and Gillespie (1974) and Sweeney and co-workers (1971) from rural Guatemalan children.

For the Solis Valley children, most deciduous tooth defects appear to occur around the last trimester and neonatally. For the permanent teeth, there is a clear central tendency towards hypoplasia occurrence at between 18 and 36 months. As weaning generally takes place in the second year in these Mexican communities, Goodman and colleagues suggest that the increased frequency of hypoplasias may result from stresses associated with weaning.

In a follow-up to the Solis study Goodman and coworkers (1992) analyzed the association between LEH, nutritional status and socioeconomic conditions. They found that LEH that developed around 2-6 years of age is associated with a decrease in achieved growth in height and weight at around ages seven to ten and a decrease in family socioeconomic status, based on material style of life. These cross sectional studies are supported by results from a prospective study. Goodman and coworkers (1991) found that children from Tezonteopan, Mexico who were given nutritional supplements during tooth formation had a 40-50% decrease in LEHs compared to non-supplemented controls.

The Tezonteopan study also provided some preliminary data suggesting that disease (especially respiratory and diarrheal) might also be key to the formation of a LEH. In a subsample it was shown that individuals with LEH also tended to have experienced more illness. And, in fact, the nutritional supplementation data may also point to the importance of disease, as nutritional supplementation is also associated with a significant decrease in the number of days ill (Chavez and Martinez 1982).

In two recent studies the first data have emerged that suggest that nutritional status and illness may have additive effects on the prevalence of enamel defects. May et al. (1993) studied LEH in Guatemalan children who received varying types and degrees of nutritional supplementation during tooth crown development. They found that individuals with LEH occurring from about birth to three years of age were more likely to have had a high frequency of illness and a low rate of calorie supplementation. Similarly, Goodman and colleagues (1992) studied rural Egyptian children and found that number of days ill and estimated caloric intake from 18 to 30 months had an additive effect on the probability of developing an LEH.

These studies of contemporary rural agricultural groups provides an important framework for contemplating the ways that subgroups such as post-weaning age children experience morbidity and mortality. Studies of contemporary populations have shown a consistent increase in the prevalence of enamel hypoplasias for groups which live in poor and underdeveloped communities. While the association of enamel defects with anthropometric status suggest a nutritional cause, it is not clear how important nutrition is, which nutrients are most critical, and how nutrition interacts with other factors such as infectious disease in the etiology of enamel defects. Regardless of the specific unknowns, enamel hypoplasias have been consistently associated with malnutrition and disease. It is our opinion that enamel defects are reliable indicators of the types of stress which we are interested in documenting for the Ridges Basin population. Although the exact etiology is unknown, the patterning and distribution of LEH by developmental time period provide a well documented method for studying the prevalence and distribution of early life stresses.

Caries Lesions

Dental caries rates can be diagnostic of the carbohydrate quality and quantity of the diet and are also of importance because of the role of caries in infirmity and tooth loss. Thus, dental caries are significant as pathological conditions and as dietary indicators. Dental caries are defined as areas of demineralization due to the action of acidogenic bacteria such as Streptococcus mutans which grow in plaque on tooth surfaces.

Caries are a multifactorial disease. Their extent depends on a variety of interacting variables including host resistance, the pathogenic agent, and the environment (Powell 1985:317). Caries rates, like other dental conditions, tend to varies in relationship to age structure. Whereas caries rates increase with age, this pattern is complicated by dental attrition and tooth loss.

Dental caries are perhaps of greatest interest to archaeologists because of their strong evolutionary relationship to changes in food production and diet. Keene (1980) finds extremely low frequencies of caries before the origins of agriculture and quantum increases after agriculture and with the introduction of refined carbohydrates. Especially for agricultural groups, understanding the relationship between caries and attrition is complex.

Armelagos and Rose (1972) have suggested that a moderate to high rate of attrition rate may have an anticariogenic effect, while slight attrition is caries promoting. This may relationship may partially explain the lower-than-expected caries rate for a maize dependent society like Ridges Basin. The attrition rate may have acted in a beneficial way to keep tooth surfaces relatively clean of acidogenic bacteria through an abrasive action.

For deciduous dentitions, three individuals with observable deciduous teeth demonstrated a spectacularly wide variation in caries rates. One individual did not have a single lesion (but just one tooth scored), another individual had one carious and seven sound teeth and the third individual, of mixed dentition, had fourteen caries in 24 teeth (58.3%). This is one of the highest frequencies of carious teeth seen in prehistoric Southwestern dentitions. It is even more remarkable for the rate of caries infestation in deciduous teeth and newly erupted permanent teeth,

The location of these deciduous caries on, mainly on occlusal surfaces, suggests that they were not secondary to hypoplastic defects and may be related to diet. Finally, no cases of deciduous canine pits, as described by Skinner and Hung (1989), were found.

For permanent dentition, caries distribution and rates at Ridges Basin are neither unusually high or low. The 48.38% of individuals (and 14% of teeth) with caries at Ridges Basin is greater than at Chaco Basin sites, Salmon Ruins, Turkey Creek and Point of Pines, almost identical to rates at La Plata, but less than at Chaco Canyon, Grasshopper, San Cristobal and Hawikku. The tentative implication of this intermediate level of caries is a diet that is certainly based on maize to some degree, but with a fair to high degree of supplementation by wild flora and fauna with a lower cariogenic potential.

In summary, dental health is generally comparable to that found at other Southwestern sites. The frequency of individuals with caries falls in the middle of a select group of Southwestern sites and is in a general range of non-intensive agriculturalists. This suggests some maize in the diet, but not unusually high.

What is most unusual is the variation in caries rates within the group. One individuals, a 25-35 year old male, has a complete set of permanent teeth without a single carious lesion, whereas the previously mentioned 12-16 year old has rampant dental caries. The cause of this variation is yet to be determined. It may be inexplicable individual variation or it may suggest some ethnic/genetic differences or extreme within group variation in diet and disease.

Osteoarthritis

An assessment of pathology is provided for adults at Ridges Basin with respect to the age-related mechanical breakdown of joint systems. This includes degenerative joint disease (DJD), and vertebral osteophytic lipping. Although highly detailed data on several locations on single bones were collected, the very small sample size for many of these observations limits a large scale investigation of osteoarthritis. Based on a combined assessment of joint systems present for individuals, adults were ranked as having an overall score of either slight, moderate, or severe DJD or vertebral changes associated with osteoarthritis (Tables 1.3-1.4).

Because DJD and vertebral osteophytosis is age related and has an onset usually in mid-adulthood that progressively affects the skeleton into old age, the assessment of osteoarthritic changes is made more difficult by the skewed age and sex distribution of males and females. For the total Ridges Basin sample, approximately 3 individuals (8.1%) are 45 or older, and this is apportioned with females having only 1 (7.1%) individuals in that age category (males have at least 2 which constitutes 11.7% of the male subpopulation). This clearly limits what can be said regarding sex differences and age-related changes for males and females.

Out of the total sample of 49 adults, only 24 could be scored for DJD. Of these, exactly half show some involvement with osteoarthritic joints. All cases of DJD are slight to moderate but the interesting trend to note is that the two females who have arthritic lipping are actually quite young (age 18 to 21 and 30+). This suggests that the arthritis may be related to trauma or biomechanical stress, and not normal wear-and-tear. The cases of osteoarthritis in the males appears to be more age related with cases appearing at age 35 to 40 and 50+.

Only 1 (2.0%) of the Ridges Basin individuals have been assigned to the age category of 50+. Approximately 1% of the Mesa Verde regional sample skeletal remains (Stodder 1987) and 6.4% of the Grasshopper Pueblo remains (Berry 1985) are over the age of 50. For Pecos, Ruff (1981) estimates that at least 13% of the individuals are over 50, and for Chaco, approximately 2% of the collection is over 50 (Akins 1986). Using different categories of aging, Ryan (1977) reports 3.9% of the remains from Puerco and Wade (1970) reports 13.6% of the Houke remains are aged over 56. This range of variability makes it difficult to know how under-represented elderly are in this population. This in turn makes it difficult to assess the pathological conditions most associated with aging.

Trauma

Evidence of trauma in skeletal remains is one of the more easily diagnosed pathologies, although even with fractures and morphological changes in bone relating to external forces there is the problem of understanding the context within which the traumatic even occurred. Evidence for trauma from the Ridges Basin burial series comes largely from either healed cranial and post-cranial fractures or are traumatic injuries that are in the remodeling (healing) phase (Tables 1.2-1.5). For two of the burials, there appeared to be peri-mortem bone breakage and spiral fractures (WA3 PHA2B, Subadult aged 5-10; WA3 3A/2B, Female aged 35-50). One burial (5LP-115 B1, Male aged 20-40) is partially burned. However, there is no indication that this burning is anything more than chance proximity to fire in a midden area.

Children and adult males and females with cranial and/or post-cranial pathology related to trauma demonstrate different frequencies vis-a-vis cranial and post-cranial involvement (Table 1.12). Four out of thirteen females (30.7%) have cranial depression fractures (healed areas where once there had been a fracture). Four males out of twelve demonstrate trauma (33.3%) but three of the cases are post-cranial fractures (largely minor) with only one male showing depression fractures on the cranium. Young children were generally free of cranial trauma; only one 5 to 10 year old (WA3 PHA2B) had a depression fracture on the occipital. Another subadult (WA3 4L3/1), aged 15, had fractured the first and second cervicle vertebrae. Post-cranial trauma for males included a healed broken foot at the first and second metatarsal and cuneiform ("P"), another had a healed and broken rib (WA 3B10a), and one male had a healed fractured finger (481/3). The one male with cranial lesions (FLC500) had two deep compression fractures on the right frontal bone.

The four females with healed cranial trauma demonstrate a number of non-lethal but potentially serious injuries that suggest violent interactions. One female has a healed broken nose (WA3/A), one has a depression fracture on the right parietal bone (5LP-117/138), one has multiple depression fractures on the forehead ("B"), and one has six well-defined puncture wounds (largely healed) and a depression fracture on the frontal bone (31/3C).

Most of the cranial wounds at Ridges Basin fit the description of depression fractures caused by blows to the head (e.g., Walker 1989; Merbs 1989; Courville 1948; Stewart and Quade 1969). The variation in overall size and dimensions of the depressions suggest that any number of implements could have been used. The location of the male fractures is on the right frontal bone. For females, the lesions are largely located around the front of the head, or on side of the head.

It is difficult to verify exactly what type of implement was used in each case of cranial trauma at Ridges Basin, but modern forensic information suggests that fractures of the head can be made with any number of blunt or sharp implements (Petty 1980). In their review of artifacts associated with warfare and hand combat, Wilcox and Haas 1994:223-224) find little evidence for the manufacture of objects solely to be used as weapons. The strongest evidence that they could garner was of two bipointed axes found with a male burial at Aztec, and wooden sword-like implements found at Chaco Canyon. While it is easy to envision a stone axe, hammerstone, core, chopper or projectile point causing damage, it is equally likely that bone, antler and wood objects could be used as well. For example, a forensic case involving cranial and post-cranial wounds similar to those at Ridges Basin were caused when being struck repeatedly with a common wooden yard broom (Bhootra 1985) not unlike the size and shape of a Pueblo digging stick (Colton 1960:96). Digging sticks were most likely common in an agricultural community such as that of the sites at Ridges Basin, and the use of such objects was primarily within the domain of men (at least in historic Pueblo societies) (Dozier 1970). Colton (1960:98) states that sometimes wooden digging sticks also had a hoe made of hafted stone, or with triangular pieces of basalt or sandstone. In addition, a variety of stone tools such as tchamahias and axes were found in the Ridges Basin Valley, and any of these items could be used to cause injury.

Bhootra (1985:567) asserts that ". . . no injury of the head is too trivial to be ignored or so serious as to be despaired of. . ." and for all deaths that result from violence, one fourth are attributed to head injuries in contemporary society. As background (taken from Gurdjian 1973:94-98), depression fractures begin with a traumatic event such as a blow to the head and this ruptures blood vessels in the bone marrow and periosteum. There is formation of a hematoma within 6 to 8 hours. This gradually is replaced by young connective tissue and it transforms into a fibrous callous. Through remodeling, this fibrous callous becomes gradually replaced with new bone. Depression fractures are produced by a force applied to just one side of the bone. The outer cortex of bone is clearly depressed inward while the underlying diploe space becomes compressed. There are three characteristics of depression fractures: There are usually fine cracks that radiate from the depressed areas; Within the depressed area, the inner table of bone is beveled at the edges; And, the surrounding areas of the depression is raised as it rebounds from the pressure build up. With healing, these all but disappear but there is usually a diagnostic depression for long periods after the trauma. The depression fracture stays depressed long after healing because of bone necrosis. Traumatic interruption of blood supply will result in the death of bone cells and a sloughing off of dead tissue.

For individuals who survive the initial effect of a blow to the head, one consequence of the process is that not enough oxygen may get to the brain (called hypoxia). Hypoxia further increases swelling and edema which in turn causes increased intracranial pressure. This can lead to brain herniation. In general, however, moderate increases in intracranial pressure can be survived, but there may be long-lasting neurological problems stemming from the healing process of the original injury. For example, children who survive head injuries are more likely to be hyperactive and have learning disabilities. Injuries to the back of the head are particularly problematic because it knocks the brain forward against the skull which can do damage to the frontal lobe (Curless 1992:164). Head injuries can produce neurological side-effects such as "amnesia, vertigo, epilepsy, poor concentration, reduced rate of information processing, fatigue, headache, irritability, emotional instability, attacks of emotional instability, and antisocial conduct" (Walker 1989:322). These symptoms can reveal themselves months or years after the original trauma. Injury to the left frontal lobe of the brain can cause personality changes (such as loss of inhibition) or hallucination (Allen et al. 1985:31). Although well healed, some of the more significant fractures (such as Ridges Basin females 117/138, 3/A, "B", and 31/3C) may have caused lasting neurological problems that may have had an effect on their ability to interact and behave in culturally appropriate ways.

Intra- or interpersonal strife may have placed a significant amount of stress on some adult members of the Ridges Basin community. Trauma is generally absent in children and benign in adult males (particularly the post-cranial trauma which was all minor). Females carry the unequal burden of traumatic cranial injuries in this group (30.7% versus 9.0%). The location and size of the cranial injuries showed that by overall dimensions and size in area, female injuries covered a larger area, involved more bony elements, often occurred in multiples, and caused internal (endocranial) damage in some cases.

Adult males did not escape morbidity relative to females, however (Table 1.13). Males were affected more often by nutritional anemia (36.6% versus 25.0%). This is odd given that adult females are generally much more at-risk for iron deficiency anemia because of pregnancy, lactation, and menstruation, all of which increase iron loss. Females do have slightly more infectious lesions than do males (15.3% versus 11.1%). These infections may be secondary to the trauma in at least one of the cases ("B").

Ridges Basin frequencies for trauma appear to be quite similar to some other Southwest groups, particularly La Plata and Gallina sites (Table 1.14). Admittedly, it is difficult to find studies from Southwest precontact material that addresses trauma in specific and quantifiable ways. An analysis of cranial trauma on the remains from the Kayenta region sites on Black Mesa (PI/II) demonstrated very low frequencies (between 4%) for both males and females. One female and two males out of 68 adults had healed fractures. The female (a small, slight eighteen year old) had three healed depression fractures. One male, a very robust twenty year old, showed a severe blow to the left side of the mouth and cheek (Martin et al. 1991).

Table 1.14 lists the frequencies compiled by Stodder (1989:187) for archaeological populations from the Greater Southwest (New Mexico, parts of Texas, south-central Colorado). Regarding these data, Stodder states that ". . . that the Gallina sample exhibits the highest reported frequencies of postcranial and cranial trauma is not surprising, as they are most often identified as warlike, with defensive architecture in relatively isolated locations" (1989:187). The relatively high rates for San Cristobal of cranial injury is suggested to be located primarily in the males ". . . suggesting that they were engaged in warfare" (1989:187). However, the distribution of cranial and post-cranial by male and female is generally not available for any of these data.

For the Pecos collection, Hooton (1930) presents a detailed inventory of cranial trauma by sex. Out of a total sample size of 581, he found 20 cases of cranial trauma, representing a 3.4% frequency. Of these 20 cases, 5 (25%) are on females and the rest are on males (75%). The depression fractures are largely located on the frontal bones, although other areas of the crania are implicated as well.

Data from precontact populations on the California coast by Walker (1989) demonstrated that healed depression fractures for groups on the coast (versus the nearby islands) were different. Cranial trauma was higher (18.5%) for the Islanders than for the coastal people (7.5%). Walker attributed this to intense competition over resources on the circumscribed island. There were no significant gender differences in the patterning of lesions, but males were more frequently involved. The back of the head was never involved, and Walker ultimately attributes the high rates of non-lethal blows to the head as part of ritual warfare, where people get hit but the blows do cause sustained injuries and death. He also attributes some of this limited combat to competition over scarce resources.

How can the patterns of trauma for the Ridges Basin females be explained? As a group, who were these women and are they distinguishable from other women? An examination of upper and lower body metrics does not reveal a subgroup that is smaller or larger in any dimensions. Cranial metrics and cranial and post-cranial discrete traits are available for such a small number of females that it is impossible to determine if there are statistically significant differences between the two groups of women.

In addition to some forms of physical violence, at least two burials appear to have been altered at the time of death resulting in cranial and long bones that have breakage patterns and spiral fractures consistent with force applied to the body around the time of death. A conservative approach was taken in the analysis of these alterations. All marks were examined under a binocular microscope which provided enough information to distinguish among marks produced by dental picks and other excavation tools, natural features of the bone such as blood vessel impressions or indentations, and other marks from deliberate cuts.

An adult female (3A/2B, aged 35-50) burial exhibited several unusual features. Cranial and post-cranial fragments were very broken but in essentially pristine condition with no rodent damage or weathering. There was a very high bone count of cranial fragments (n=42) that were all approximately one to two inch square pieces. Some of the cranial fragments appear to have cutmarks, although none of these are definitely attributable to dismembering or defleshing. Several of the cranial pieces also have punctures with adherent flakes.

Of the post-cranial remains, six long bone fragments have smooth spiral fracture patterns. Fracture morphology and timing of breaks was a challenging problem. Distinguishing peri-mortem from post-mortem breakage is extremely difficult and there is not a set of standard criteria in use for their determinations (Bonnichsen 1983; Morlan 1983). Gifford-Gonzalez (1989:188) favors a strictly descriptive typology rather than one imputing cause. She records three major break shapes for compact bone (transverse, longitudinal, and spiral) and notes the texture of the break surface as smooth or stepped.

The child (WA3 PHA, aged 2-5) burial was comprised only of a small number of cranial fragments (n=9) and 3 ribs. The cranial pieces exhibit what appear to be peri-mortem fractures from multiple blows to the head. Frayer (1993:8) gives three main criteria for distinguishing peri-mortem from post-mortem holes in the cranial vault. These are the beveling of the fracture walls, increasing from the ecto- to the endocranial surface, hinge fractures and spalling of the endocranial surface, and compression fractures radiating from the hole located on the ectocranial surface. Milner and colleagues (1991:583) describe peri-mortem cranial injuries as holes with the internal edges bordered by areas where pieces of the table and diploe have broken off. Cracks radiate out from the area of the blow. Citing forensic information, White (1992: 133-134) notes that the common fracture pattern is internal vault release, where the inner or endocranial table is released from the diploe. He also notes that breaks and cracks often follow meningeal impressions and sutures (1992:172).

The pattern of breakage for the Ridges Basin child appear to fit the criteria as proposed by Frayer with beveling of the fracture walls increasing from the outer to the inner surface. Adherent flakes and cutmarks are also present on some of the cranial pieces.

The analysis of both of these individuals with suspicious possible peri-mortem alterations is that there is no archaeological context. In the absence of a site report or provenience, it is difficult to interpret the full extent of these alternations. Also, these bones had been processed with a resin or preservative, making some of the observations difficult.

Faced with multiple causation for virtually every modification that can also be attributed to humans, a great deal of caution is necessary when evaluating breakage. As noted, few of those analyzing human bone define how they distinguish peri-mortem from post- or ante-mortem breaks. The assumption many make is that if the fracture is smooth, the bone was fresh and damage occurred around the time of death. These, combined with cutmarks and burned bones, are interpreted as suggesting abusive treatment of the dead and possibly cannibalism (e.g., Turner 1993; White 1992).

Without better mortuary and archaeological information on these remains from Ridges Basin, the interpretation will be left for the moment as some form of cultural modification. In 1939, Earl Morris, reporting his finds in the La Plata Valley of Colorado and New Mexico, described human bone assemblages similar to those recovered during the current project. At Site 41, he found individuals whose remains had been gathered up and tossed in a disorderly heap, others that were placed in empty rooms and left exposed until covered by natural agencies, and scrambled skeletons he believed were dug up during construction activities and tossed into abandoned chambers or placed in a shallow pit along with trash (1939:90-95). He also describes an assemblage attributed to the "residuum of a cannibalistic rite or orgy." Beneath a room in a pit 2.45 m in diameter and 90 cm deep were refuse and bones from at least six individuals. Crania from the four adults were split and most other elements were split and broken into pieces. Some were partially burned (1939:105).

A rockshelter near Site 23 (a large Basketmaker III-Pueblo I site just across the state line, held the remains of two individuals embedded in a burned layer and inside a large corrugated jar. The skulls were broken, long bones splintered, and many were charred (Morris 1939:75: White 1992:368). Morris interprets these as the result of occasional strife between autonomous units where the inhabitants of one valley may have attacked their better off neighbors when faced with local crop failure. Great house construction was seen as a defense against attack by raiders from the periphery (1939:43).

In summarizing human bone assemblages where cannibalism has been suggested, White identified a number of similarities in skeletal representation and bone modification. All have burning, considerable breakage, and are in good condition. Percussion striae and cut marks are found in some but not all (1992:349-351). Examination of White's summaries of the better documented site assemblages (1992:367-381) and some of the more recently reported assemblages (this volume; Darling 1993; Ogilvie and Hilton 1993:97-128) from the Four Corners area confirms that all or nearly all have burning, cut marks, and considerable breakage often accompanied by percussion pits, spalls, and impact notches. Dates vary considerably ranging from Pueblo I (Cottonwood Canyon, Utah and 423-131, New Mexico) to early historic periods (Polacca Wash, Arizona). Four assemblages are attributed to Early Pueblo II (Sambrito Village, Sanchez Site, Burnt Mesa, and 423-124 in New Mexico), three to Pueblo II (Porter Pueblo or 5 MT1, Colorado, Leroux Wash, Arizona, Yellow Jacket or 5 MT3, Colorado), two to Late Pueblo II - Early Pueblo III (Big Hawk Valley, Arizona and Marshville Hamlet, Colorado), three to Early Pueblo III (Ridges Basin 41, New Mexico, Mancos 5MTURM-2346, Colorado, and Grinnell, Colorado), one from Pueblo III (LA 37592, New Mexico), and one undated but probably Pueblo II or Pueblo III (Ridges Basin 23, New Mexico). There are presumably more such sites in the Southwest region reported elsewhere (e.g. Turner 1993).

Darling (1993) favors an explanation where violence functioned as a leveling mechanism that minimized status rivalry and ensured egalitarianism (1993:15, citing Baker 1990). Witchcraft and witch accusation are thus viewed as adjustive responses that reduced tensions resulting from stress within the community. Accusation generally ensures social cooperation and may deter factionalism. Slaying of witches in the Southwest peaked during periods of drought, epidemics, and other stress provoking events (Darling 1993:23-24). Subsistence stress in the highly unpredictable environment of the Four Corners area, as well as sociopolitical shifts, could have produced situations where witch accusation and execution were an adaptive response (1993:24). Historical witch accusation included entire families, groups, and even communities (1993:30). Violent dismemberment, destruction, and burning of a witch's body served to prevent the witch's return. Cannibalism of a witch's remains is unlikely since this act is one attributed to witches and fear of becoming a witch would deter such behavior (1993:44). Darling's explanation fits with the evidence from many of the sites reviewed. Although it is also a form of institutionalized violence, the motivating factors are far more complex than those proposed by Turner (1993). The witchcraft model also would allow for a great deal of variability in how it is expressed and this could account for the variability in the disarticulated assemblages among regions and through time.

That some remains from Ridges Basin were modified and altered around the time of death is clear; the behaviors that produced the remains are not so clear. Cannibalism is only one of several possible competing hypotheses for modified and altered remains. Witchcraft and associated ritual is a conceivable alternative working hypothesis. Likewise, warfare, conflict, "headhunting," and ritualized dismemberment are others. And while all of these motivating factors behind the violence may be seen as a form of institutionalized behavior, it could be argued that regional and temporal variability must first be thoroughly understood. As Ogilvie and Hilton (1993:128) suggest, secondary mortuary practices may have been practiced with regularity and thus "offers reasonable alternatives to a cannibalism explanation". They also caution that "any interpretation based on observations from these limited data would be strictly conjectural."

CONCLUSIONS: HEALTH PROFILE FOR RIDGES BASIN

The inventory of pathological conditions for the Ridges Basin population suggest a group that was, on the whole, doing quite well. They were minimally bothered with the normal range of common ailments ranging from iron deficiency anemia to easily transmissible diseases such as staph and strep. Taken as a whole, the indicators of physiological disruption suggest that these problems contributed to morbidity, but not to mortality. The general physiological involvement is slight to moderate for anemia and infection, and when compared with other Southwest groups, it is on the low end of the frequency distribution. The chronology for dental defects at Ridges Basin likewise fall within the low end of the frequencies for contemporaneous Southwest groups. Adult morphology and stature falls well within expected ranges of variability for extinct and extant Pueblo groups.

The picture that emerges from this is one of an agricultural population that was doing well given the circumstances of subsistence farming. Anemia and infectious disease are expected outcomes of group living and agrarian lifeways. In comparison to nearby groups in the La Plata, Mesa Verde and Chaco Canyon regions, Ridges Basin individuals seem to be faring quite well, if not better than expected.

This picture of relative good health is shadowed by the frequencies of trauma found in the female subpopulation. The high frequencies of cranial trauma suggests signs of strife and troubled times for some living at Ridges Basin. Their "relatedness" to the group is unknown and we are left to speculate on the reasons behind the physical injuries inflicted.

Sixty-seven burials representing the full range of ages and sexes were recovered. Many of the larger studies on human remains from the Southwest have focused on adaptation to scarce resources and marginal environmental conditions. The Ridges Basin context provides an interesting complement to these studies because although agricultural productivity may have been moderate, wild plants and animals were fairly abundant throughout the occupation (Duke 1985). The goals of this study included demographic and health profiles for the people living at Ridges Basin. We wanted to contribute to baseline data for this region that could be compared with data from other Southwest groups, with the eventual goal of providing a larger regional synthesis of the relationships between biological well-being and cultural context.

The demographic analysis of the burial population was hampered by under-representation of children and elderly. The under-representation of the most elderly age category suggests one of two things: either the older individuals were not recovered from the sites or the population as a whole had few elderly in its midst. The age composition of 5.9% infants under age 2, 13.4% children between 1 and 9, 5.9% teens between 10 and 20, and 74.7% adults is quite different from the age structure distribution for Black Mesa, Mesa Verde and La Plata.

It is clear that the Ridges Basin communities were committed to a maize diet as dental health reveals a pattern of wear and disease common to traditional agriculturalists. Caries results from an infectious disease process characterized by a demineralization of the dental tissues by organic acids. These acids come from a fermentation of dietary carbohydrates. High frequencies have been noted in a number of precontact groups in the Southwest (Stodder 1987). The Ridges Basin frequencies are comparable to other groups in the Southwest but on the low end suggesting that other foodstuffs complemented the maize diet.

Although exact dietary composition beyond maize is not clear, an examination of childhood health and growth and development can suggest the adequacy of diet. Porotic hyperostosis, a response to iron deficiency anemia in the Southwest, is an indicator of physiological response to a decrease in the body's ability to transport oxygen to tissues. It results in an expansion of the thinner bones in the body because of an attempt to produce more red blood cells. The outcome is bone which appears porous on the vault or in the orbits. The frequency data on this lesion for the Ridges Basin demonstrates that there were relatively few cases with severe involvement.

Comparing the overall frequency of porotic hyperostosis in children between birth and age 10, the Ridges Basin sample is closest to the Pueblo Bonito series (a problematic skeletal sample because of its under-representation of children in general, and its presumed elite status). These frequencies include all expressions of severity as well as different stages of healing but the point is that Ridges Basin frequencies are generally about half that of some other Southwest skeletal collections. The root causes of iron deficiency are multiple and complex and may include poor diet, lack of sanitation, infections, and other childhood diseases. Whatever the basis, the Ridges Basin data suggest better overall health for its children.

This is supported by an additional data set. Enamel developmental defects in the form of hypoplastic lines are indelible markers of childhood physiological disruption. They result when some systemic health problem shuts down the formation of new enamel. The resulting defects were assigned an age of occurrence and they provide good documentation of disturbances during childhood. With a frequency of 54.8% that clusters around the ages of 2-6, enamel defects suggest that Ridges Basin children do not carry the burden of morbidity that other Southwestern groups do. The average defect of one hypoplastic line or less is considerably lower than that reported for many Southwest groups. Compared with other Southwest series such as Black Mesa, Mesa Verde, Yellow Jacket, Dolores, and Sand Canyon, it suggests that the prevalence of suboptimal conditions for children, and the resulting burden of childhood sickness in the Ridges Basin community was less than for other Southwest groups.

Just as the bone lesions for iron deficiency were slight and mild in expression, the occurrence of systemic, non-specific infections on the outer shafts of long bones was likewise generally mild in expression. Compared with cases documented at other Southwest sites, where the disease response was typically severe and active, the Ridges Basin Valley residents seemed to have been buffered from severe infection. Comparing total population frequencies across different Southwest sites, Ridges Basin does not stand out as having frequencies inconsistent with other sites, and although these data do not reflect it, all of the Ridges Basin cases are slight to moderate. Black Mesa, Chaco Canyon small sites, and Dolores had largely moderate to severe cases of infectious disease. The large protohistoric sites also demonstrated many severe cases.

Turning to the adult segment of the population, there are some notable patterns among males and females. Anemia was an equal liability for both males (36.6%) and females (25.0%) suggesting that it was a function of shared lifestyle events. Similar patterns emerged for transmissible infectious disease with males (11.1%) and females (15.3%) sharing similar morbidity loads.

Frequencies of cranial and post-cranial trauma (represented by healed or healing fractures) demonstrate disparate trends across subgroups. Children were free of cranial fractures; only one child had a post-cranial fracture (9.0%). There was one case of male cranial trauma: one fifty or older male had a healed compression fracture of the right parietal. Male post-cranial fractures included a three cases of mild healed fractures of the hand, foot, and ribs. These lower body fractures did not co-occur with head trauma. On the other hand, four females show healed compression fractures on the head, and one female demonstrated lower body traumatic circumstances. The kinds of compression fractures found on females suggest non-lethal blows to the head with blunt objects.

These patterns are provocative but we are limited in our ability to fully explain them. The excavation and curation practices have left the burials largely bereft of mortuary and archaeological context. Many of the burials are now only represented by crania.

Synthesizing data from the human remains recovered as part of the Ridges Basin Animas-La Plata Project has perhaps raised more questions than it was able to answer. The goal of the analysis was not to provide descriptive forensics (which we argue is limiting and reductionist). Rather, the research agenda included a broadly biocultural perspective that focused on questions framed out of a knowledge of the archaeological context within which the remains were found.

This particular skeletal collection occupies a unique space within Southwest studies for a number of reasons. The Ridges Basin region has been underutilized in the reconstruction of precontact adaptation in the Four Corners region. Furthermore, Ridges Basin was undergoing a shift in settlement and housing during the time period represented by the human remains (BM III/PI). For these reasons warrants close analysis.

Table 1.1 Data Collection Strategy for Ridges Basin: Summary of Skeletal and Dental Indicators of Stress

Indicator	Requirements	Subgroups at Risk	General Comments
Age/Sex Composition	Well-represented skeletal population	All	Age-at-death represents one of the better overall indicators of adaptation; indicates patterns of mortality
Porotic hyperostosis	Cranium	Subadults Females	Related to iron deficiency anemia; can provide indication of severity and timing; indicates patterns of morbidity
Periosteal reaction	Long bones	All	Related to non-specific infectious disease; can distinguish localized from systemic infection and provides indication of timing and severity; indicates patterns of morbidity
Enamel defects	Any teeth	.5 in utero to age 7	Related to acute or chronic physiological disruption; can specify age-of-occurrence and peak occurrence of morbidity
Subadult size	Subadults with dental age and	Subadults	Represents the summation of factors that may affect growth and development; can indicate the timing of greatest stress
Adult stature	Adult long bones	Subadults	Summation of pre-adult factors; short stature is often a response to undernutrition or chronic illness
Osteoarthritis	Vertebrae and joints	Adults	Indication of occupational and biomechanical wear-and-tear on joint system and the vetebral column
Trauma	All bones	All	Indication of accidents and violence
Dental caries	Any teeth	All	Indication of refined carbohydrate diet; can lead to infection and tooth loss

Table 1.2 Subadult Human Remains from Ridges Basin Collection

ID	Sex	Age	Fem L	Cran	Post-C	Trauma	Anemia	Infect	Arth	Caries
481/6	?	Fetal	?	✓	✓	?	?	?		?
488/5	?	Fetal	?	✓	✓	?	None	None		?
5	?	nb-.5	?		✓	?	?	None		?
481/7	?	nb-1	?	✓	✓	?	?	Mod-Act		?
483/1	?	1-1.5	?	✓	✓	None	None	None		?
4/1	?	1-3	?	✓	✓	None	SL-Rem	Mod-Act		?
3/11C	?	2-6	?	✓		None	?	?		?
483/2	?	3-4	?	✓	✓	None	None	None		?
483.4	?	3	?	✓	✓	None	SL-Rem	None		?
481.4	?	5-6	?	✓	✓	?	?	?		?
PHA2B	?	5-10	?	✓	✓	P.M.	None	None		?
"D"	?	8-12	?	✓		?	?	?		0/1
FA1	?	10-15	?	✓	✓	None	None	None		?
"U"	?	12-18	332		✓	None	?	None		?
4L3/1	?	12-16	320	✓	✓	PC-F	SL-Rem	None		14/24
3A/B	?	16-20	?	✓		?	?	?		1/8
"O"	?	Subadult	?	✓		?	None	?		?
481/2	?	Subadult	?	✓	✓	?	?	?		?

Note: Ages are provided as age ranges. Femoral length (Fem L) is provided in mm. Cranial (Cran) and post-cranial (Post-C) columns are checked if skeletal material was present for analysis. Trauma, anemia, infection (Infect), osteoarthritis (Arth) and caries columns have a (?) when no observations were possible. Pathologies are denoted as slight (SL), moderate (Mod) or Severe (Sev), and status of the lesions are denoted as active (Act) or remodeled/healing (Rem). Traumatic lesions are either post-cranial fractures (PC-F) or cranial depression fractures (C-DF). Cases of peri-mortem alteration (such as spiral

Table 1.3 Male Human Remains from Ridges Basin Collection

ID	Sex	Age	Fem L	Cran	Post-C	Trauma	Anemia	Infect	Arth	Caries
4LI/1a	M	19-21	439	✓	✓	None	Mod-Rem	None	None	2/9
138	(M)	18-20	?	✓	✓	?	?	None	None	?
481/5	(M)	20-30	?		✓	?	?	?	?	?
3B/10A	M	20-24	439	✓	✓	PC-F	Sl-Act	Sl-Act	None	0/14
"Q"	M	20-35	?		✓	None	?	None	None	?
"R"	M	25-35	?	✓		?	None	?	?	0/32
481/1	M	25-30	440	✓	✓	None	Sl-Rem	None	None	3/28
FLC501	(M)	25-30	?	✓		None	None	?	?	0/10
3/11B	(M)	25-35	?	✓	✓	?	?	?	?	0/16
3/B11a	M	25-30	?	✓	✓	None	None	None	None	0/1
66221a	(M)	30-40	?	✓		None	Sl-Rem	?	?	0/8
"I"	M	35+	?	✓		None	None	?	?	4/7
481/3	M	35-40	425	✓	✓	PC-F	None	None	Sl-Mod	1/25
115	(M)	35	?	✓		?	?	?	?	0/23
"J"	(M)	40+	?	✓		None	Sl-Rem	?	?	0/8
"P"	M	40-45	?		✓	PC-F	?	None	None	?
FLC500	M	50+	453	✓		C-DPs	None	None	Sl-Mod	0/3

Note: Ages are provided as age ranges. Femoral length (Fem L) is provided in mm. Cranial (Cran) and post-cranial (Post-C) columns are checked if skeletal material was present for analysis. Trauma, anemia, infection (Infect), osteoarthritis (Arth) and caries columns have a (?) when no observations were possible. Pathologies are denoted as slight (SL), moderate (Mod) or Severe (Sev), and status of the lesions are denoted as active (Act) or remodeled/healing (Rem). Traumatic lesions are either post-cranial fractures (PC-F) or cranial depression fractures (C-DF). Cases of peri-mortem alteration (such as spiral fractures and breakage) are denoted as (P.M.). Caries are noted as numbers of caries per teeth present for analysis.

Table 1.4 Female Human Remains from Ridges Basin Collection

ID	Sex	Age	Fem L	Cran	Post-C	Trauma	Anemia	Infect	Arth	Caries
117/138	F	18-20	?	✓	✓	C-DF	None	None	SL-Mod	?
RF/145	(F)	20-24	384		✓	None	?	None	None	?
3/A	(F)	20	400	✓	✓	C-DF	None	None	None	0/9
4LI/1	F	20-30	410		✓	None	?	None	None	?
662221	F	25-26	385		✓	None	?	None	None	?
3A/LB	F	30+	?		✓	None	?	None	SL-Mod	?
483/3	F	25-35	?	✓	✓	None	None	None	None	0/17
117/1232	F	20-40	?		✓	None	?	None	None	?
"B"	(F)	25-30	?	✓		C-DF	Mod-Rem	Mod-Rem	?	4/13
"L"	(F)	20-30	?	✓		None	None	?	?	2/20
"S"	(F)	25-35	?	✓	✓	None	None	None	None	2/17
3A/2B	F	35-50	?	✓	✓	P-M	Mod-Rem	Mod-Act	None	?
135	F	35+	404		✓	None	?	None	None	?
31/3C	F	45+	?	✓	✓	C-DF	None	None	None	1/23

Note: Ages are provided as age ranges. Femoral length (Fem L) is provided in mm. Cranial (Cran) and post-cranial (Post-C) columns are checked if skeletal material was present for analysis. Trauma, anemia, infection (Infect), osteoarthritis (Arth) and caries columns have a (?) when no observations were possible. Pathologies are denoted as slight (SL), moderate (Mod) or Severe (Sev), and status of the lesions are denoted as active (Act) or remodeled/healing (Rem). Traumatic lesions are either post-cranial fractures (PC-F) or cranial depression fractures (C-DF). Cases of peri-mortem alteration (such as spiral fractures and breakage) are denoted as (P.M.). Caries are noted as numbers of caries per teeth present for analysis.

Table 1.5 Adult Human Remains of Unknown Sex or Age from Ridges Basin Collection

ID	Sex	Age	Fem L	Cran	Post-C	Trauma	Anemia	Infect	Arth	Caries
"H"	?	16-20	?	✓		None	Mod-Rem	?	?	0/14
117/4	?	20-30	?		✓	?	?	?	?	?
"E"	?	20-30	?	✓		?	?	?	?	0/3
"G"	?	20-30	?	✓		None	None	?	?	1/4
3A/2C	?	25-40	?	✓		?	?	?	?	?
"M"	?	25-40	?	✓		?	?	?	?	1/8
"A"	?	35-45	?	✓		None	Mod-Rem	?	?	7/19
"C"	?	25-35	?	✓		?	?	?	?	1/13
3B/106	?	30-45	?	✓		C-DP	Mod-Rem	?	?	0/20
3A/A	?	35-45	?	✓		C-DF	?	?	?	0/12
"F"	?	30-45	?	✓		?	?	?	?	1/3
117	?	40+	?	✓	✓	None	None	None	None	1/23
"K"	?	45+	?	✓		None	None	?	?	4/17
115/1	(M)	Adult	?		✓	None		None	None	?
3/B	?	Adult	?	✓		?	?	?	?	0/12
3/C	?	Adult	?	✓		?	?	?	?	?
"N"	?	Adult	?	✓		?	Sl-Rem	?	?	?
"T"	?	Adult	440		✓	None	?	None	None	?

Note: Ages are provided as age ranges. Femoral length (Fem L) is provided in mm. Cranial (Cran) and post-cranial (Post-C) columns are checked if skeletal material was present for analysis. Trauma, anemia, infection (Infect), osteoarthritis (Arth) and caries columns have a (?) when no observations were possible. Pathologies are denoted as slight (SL), moderate (Mod) or Severe (Sev), and status of the lesions are denoted as active (Act) or remodeled/healing (Rem). Traumatic lesions are either post-cranial fractures (PC-F) or cranial depression fractures (C-DF). Cases of peri-mortem alteration (such as spiral fractures and breakage) is denoted as (P.M.). Caries are noted as numbers of caries per teeth present for analysis.

Table 1.6 Ridges Basin Distribution of Age-at-death (n = 67)

Age	Number	Breakdown by Sex	
		Males (17)	Females (14)
Fetal	2		
nb - .9	2		
1 - 4.9	7		
5 - 9.9	3		
10 - 14.9	3		
15 - 19.9	1		
TOTAL n	16		
20 - 24.9	8	4	4
25 - 29.9	7	6	1
30 - 34.9	7	1	6
35 - 39.9	5	3	2
40 - 44.9	3	2	1
45 - 49.9	0	0	0
50	2	1	1
Unknown	18		
TOTAL n	49		

Table 1.7 Age Composition for New World Prehistoric Sites

	Percentage			
Population (N)	<1	1-9	10-18	>18
Ridges Basin (67)	5.9	13.4	5.9	74.7
La Plata (67)	6.0	30.3	9.0	54.5
Mesa Verde Early (150)	10.6	18.0	14.0	57.3
Mesa Verde Late (178)	16.8	18.5	23.5	48.6
Pueblo Bonito (93)	1.0	16.1	17.2	40.4
Black Mesa (165)	10.4	24.2	14.5	50.9
Casas Grandes (612)	10.0	22.0	14.0	54.0
Pecos Pueblo (1722)	18.7	14.0	8.0	59.0
Tlajinga, Mexico (166)	41.3	10.3	10.6	38.6
Arikara Villages (1487)	31.5	24.0	9.5	45.5
Libben, Ohio (1239)	18.0	22.0	14.0	46.0

Compiled from Martin et al. (1991), Storey (1988), and Nelson et al. (1994).
Sample size is in parentheses.

Table 1.8 Porotic Hyperostosis: Comparison Across Southwest Groups

Site	n	Period	Subadults Age 0-10	Total Sample	Ref
Ridges Basin	67	BMIII/PI	0.285	0.321	
La Plata Valley	67	PII-III	0.611	0.395	
Chaco Canyon	32	PII-III	0.83	0.718	1
Pueblo Bonito	20	PII	0.255		1
Mesa Verde Region	93	PII-III	0.878	0.59	2
Dolores	33	PII	0.82		2

Abbreviations and symbold used: Ref=Feferences cited. 1=Stodder (1989:178); 2=Stodder (1987); n=total number of sample available for assessment of porotic hyperostosis.

Table 1.9 Periosteal Reactions: Comparison Across Southwest Groups

Site	n	Period	Total Sample	Ref
Ridges Basin	67	BMIII-PI	15.5%	
Black Mesa	178	PI/II	22.4%	4
Chaco Canyon	135	PI-III	17.0%	1
Chaco Basin	36	PI-III	8.00%	1
La Plata Valley	67	PII-III	16.2%	5
Mesa Verde	179	PI-III	2.7%	2
Dolores	66	PII-III	9.0%	3
Salmon Ruin	97	PII-III	6.0%	1

Abbreviations and symbols: Ref=REeference cited. 1=Stodder (1989:184); 2=Miles (1966:37-41); 3=Stodder (1987); 4=Martin et al. (1991). n=total number of samples available for assessment of peristeal reaction on long bones.

Table 1.10 Stature for Select Southwest Populations

Group	Male	Female	M/F Ratio	Ref
Ridges Basin	165.6	152.4	1.086	
La Plata	161.4	152.2	1.060	
Pueblo Bonito	162.5	155.5	1.045	1
Puye	160.0	149.5	1.070	1
Arroyo Hondo	162.0	148.5	1.091	2
Point of Pines (Middle)	159.4	150.7	1.058	3
Point of Pines (Late)	162.6	151.3	1.075	3
Black Mesa (Early)	167.0	156.5	1.067	4
Black Mesa (Late)	163.1	152.5	1.070	4
Carter Ranch	162.2	147.7	1.098	5
Hawikku	160.5	150.0	1.070	1
Transwestern Anasazi	165.7	154.0	1.075	6
Chaco (Small site)	164.7	157.4	1.046	7
Mesa Verde	162.1	155.6	1.041	8
1930s Pueblo Indians	163.7	152.0	1.076	9

Ref=references: (1) Corruccini 1974; (2) Palkovich 1980; (3) Bennett 1973; (4) Martin et al. 1991; (5) Danforth et al. 1994; (6) Herrmann 1993; (7) Akins 1986; (8) Stodder 1987; (9) Hrdlicka 1935.

Table 1.11 Frequencies of Individuals with Dental Caries on the Permanent Dentition

Sample/Site	Stage/Date	N	%
Ridges Basin	BM II/Pueblo I	(32)	48
La Plata	Pueblo II-Pueblo III	(32)	44
Dolores	700-1100	(24)	71
Black Mesa	800-1150	(64)	26
Chaco Basin	Pueblo I-Pueblo III	(49)	8
Chaco Canyon	Pueblo I-Pueblo III	(27)	85
Salmon Ruin	Pueblo II-Pueblo III	(20)	20
Turkey Creek	1000-1285	(91)	9
Point of Pines	1000-1450	(76)	29
Sopris Phase	1150-1250	(24)	13
Pindi Pueblo	Pueblo II-Pueblo IV	(52)	13
Jornada Sites	900-1400	(45)	13
Paa 'ko, Tijeras	Pueblo III-Pueblo IV	(149)	23
Grasshopper	1275-1400	(168)	52
Pottery Mound	Pueblo IV	(49)	76
El Morro	Pueblo IV	(15)	53
Pecos Precontact	1300-1550	(126)	44
Pecos Protohistoric	1550-1600	(68)	53
Pecos Historic	1600-1800	(68)	43
San Cristobal	1300-Historic	(136)	57
Hawikku	1300-Historic	(98)	53

Compiled from Martin et al. (1991) and Stodder (1989).

Table 1.12 Frequencies: Healed Trauma

	Children	Males	Females
Cranial	0/7 [0%]	1/11 [9.0%]	4/13 [30.7%]
Post-cranial	1/11 [9.0%]	3/12 [25.0%]	1/11 [9.0%]

Table 1.13 Gender Differences at Ridges Basin

	Male	Female
Anemia	4/11 [36.3%]	2/8 [25.0%]
Infection	1/9 [11.1%]	2/13 [15.3%]
Stature	165.6	152.4

Table 1.14 Frequencies of Traumatic Injury Across Southwest Groups

		Cranial		Postcranial	
Site/Sample	Stage/Date	N	%	N	%
Ridges Basin	Basketmaker III/Pueblo I	(31)	16	(34)	15
Chaco Canyon	Pueblo I-Pueblo III				
Gallina Sites	Pueblo I-Pueblo III	(41)	20	(41)	22
Sopris Phase	1150-1250	(25)	4	(25)	0
Jornada Sites	900-1400				
La Plata	Pueblo II-Pueblo III	(49)	18	(49)	16
Pindi Pueblo	Pueblo II-Pueblo IV				
Paa 'ko	Pueblo II-Pueblo IV	(57)	3	(57)	16
Arroyo Hondo	Pueblo IV				
Tijeras Pueblo	Pueblo IV	(64)	2	(64)	14
Pottery Mound	Pueblo IV				
El Morro	Pueblo IV	(26)	4	(26)	8
Cochiti	Pueblo IV	(101)	4	(101)	5
Pecos Pueblo	Pueblo III-Historic	(581)	5	(581)	4
San Cristobal	Pueblo IV-Historic	(247)	8	(232)	14
Hawikku	Pueblo IV-Historic	(181)	5	(151)	17
San Antonio de Padua	Pueblo IV-Historic	(40)	5	(40)	0

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