LINEAR ENAMEL HYPOPLASIA:
AN ANALYSIS OF HEALTH DISPARITIES BETWEEN THE EARLY INTERMEDIATE PERIOD AND MIDDLE HORIZON OF NASCA, PERU

By

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ABSTRACT

ELIZABETH MOORE. Linear Enamel Hypoplasia: An Analysis of Health Disparities of the Peruvian Coast. (Under the direction of DR. DENNIS OGBURN)

There has been an abundance of research, archaeological and other, on the Nasca culture and linear enamel hypoplasia (LEH) separately. However, there is no literature specifically on Nasca and LEH analysis comparing the Early Intermediate Period (EIP) stages of Early Nasca and Late Nasca, and the Middle Horizon period (MH). The research detailed here shows there are evident disparities in LEH between Nasca males and females correlating to status, cranial vault modification (CVM), and trophy heads, between the EIP and MH. On the other hand, fluctuations in LEH severity are similar between sexes due to shared experiences of stress linked to changes in environmental conditions and in socio-political organization. I utilized macroscopic observations of linear enamel hypoplasia on 47 Nasca individuals from the Kroeber collection from the Field Museum in Chicago, Illinois. Through this project, I found statistical significance between sex and trophy heads, cranial modification and LEH presence, and LEH between Early and Late Nasca periods. I conclude that while not statistically significant, but approaching significance, females tend to be more negatively impacted than males from similar stressors. Overall, health status deteriorated over time showing environmental changes and socio-political changes leading up to and during Wari imperial occupation had a negative effect on Nasca individuals, despite/regardless of status or sex. This presents a larger understanding on inequality and skeletal manifestations of such as well as a larger understanding of effects of environmental and socio-political stress on the skeleton.

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Last, but certainly not least, my warm and heartfelt thanks go to my husband, Zachary, for his tremendous support and hope he gave me throughout this entire process. Without that hope and support, this thesis would not have been possible. You were always there, wherever and whenever. Thank you.

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LIST OF ABBREVIATIONS

LEH: Linear Enamel Hypoplasia

EH: Enamel Hypoplasia

EIP: Early Intermediate Period

MH: Middle Horizon

CVM: Cranial Vault Modification

ACD: Artificial Cranial Deformation

ICM: Intentional Cranial Modification

CM: Cranial Modification

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CHAPTER 1: INTRODUCTION

Tooth enamel defects are linked to physiological stress impacts on the human skeleton. These defects often correlate with other skeletal indicators such as Harris Lines (growth arrest lines, typically on the long bones). Stress may impact individuals differently, leading to disparity in the development of skeletal markers. Previous research has shown that drought, population, aggregation, and Wari imperial conquest resulted in detrimental health impacts on the Nasca population of Peru from the Early Intermediate Period (EIP) to the Middle Horizon (MH) (Kellner 2002). The specific aims of this study are to determine how the analysis of linear enamel hypoplasia (LEH) of individuals from Nasca, Peru aids in the understanding of possible health disparities between males and females in the region between the Early Intermediate Period (EIP), ca. AD 1-750, and the Middle Horizon (MH), ca. AD 750-1000.

With this project, I am addressing the questions: Were enamel defects, specifically linear enamel hypoplasia, prevalent within this population? Are these defects more prevalent in males or females? Or is there no statistically significant difference between them? Did LEH prevalence or severity differ between the Early Intermediate Period and Middle Horizon? If so, what does this indicate for the impact of stress during childhood between Nasca females and males? How might the osteological paradox impact this research? This study utilizes Kroeber's Peruvian osteological collection from the Field Museum, specifically individuals from the Early Intermediate Period to the Middle Horizon. My hypothesis was that there may be disparities based on sex within Nasca, however, there should be similar fluctuations over time in the region because of similarities in experiencing the environmental and socio-political changes occurring at this time.

CHAPTER 2: BACKGROUND INFORMATION

2.1 Archaeology of Nasca

Chronology: The Early Intermediate Period to the Middle Horizon

The Nasca culture was centered in the Rio Grande de Nasca drainage on the South Coast of Peru (Figure 1). Multiple archaeological studies have been conducted in this region with a focus on Nasca (e.g., Carmichael 1988; Conlee 2000; Hrdlicka 1914; Proulx 2001; Silverman 1993, 2019; Tello 1918; Uhle 1914). My study focuses on the Early Intermediate Period into the Middle Horizon. Following the initial complexity and population growth of the Early Horizon, the Early Intermediate Period (AD 1-750) denotes great cultural flourishing in the Nasca drainage (Kellner 2002; Silverman 1993; Carmichael 1988). Based on ceramic chronologies and radiocarbon dating, the EIP has been further divided between three cultural sections: Early Nasca, Middle/Transitional Nasca, and the Late Nasca (Strong 1957; Carmichael 2013; Conlee 2016). At this time, the south coast Nasca culture was organized as a series of simple chiefdoms. This culture produced incredible ceramic and textile art that strongly influenced the later Wari culture, which was present in the area for around 400 years. Around AD 500 in the Middle/Transitional Nasca, the society underwent a cultural upheaval resulting in it being reorganized into a series of more complex chiefdoms and warfare became more prominent (Schreiber 2001).

Horizons & Periods	Culture Name	Phases	Approx. Dates
Middle Horizon (MH)	Wari Loro	8,9	A.D. 750-1000
	Late Nasca	6, 7	A.D. 550-750
	Middle/Transitional	5	A.D. 450-550
Early Intermediate Period (EIP)	Early Nasca	2, 3, 4	A.D. 1-450

Table 1. Chronological of Nasca, Peru From the Early Intermediate Period to the Middle Horizon.

The Wari empire, also known as the Huari, is characterized by rapid expansion during the Middle Horizon (AD 750-1000). After the Middle Horizon and the end of the Nasca culture, the Late Intermediate Period (AD 1000-1476) follows the Wari Imperial collapse, and is marked by socio-political reorganization, which was later followed by the beginning of Inca imperialism (Kroeber 1998; Williams et al. 2001). "Because of their supposedly strong ties to the Wari, Menzel (1977:52) posits that Wari collapse at the end of the Middle Horizon had severe effects on Nasca populations," (Kellner 2002). However, the extent of health impacts correlated to the stress of such a reorganization and changing of empires between the Early Intermediate Period and Middle Horizon is what I am examining here.

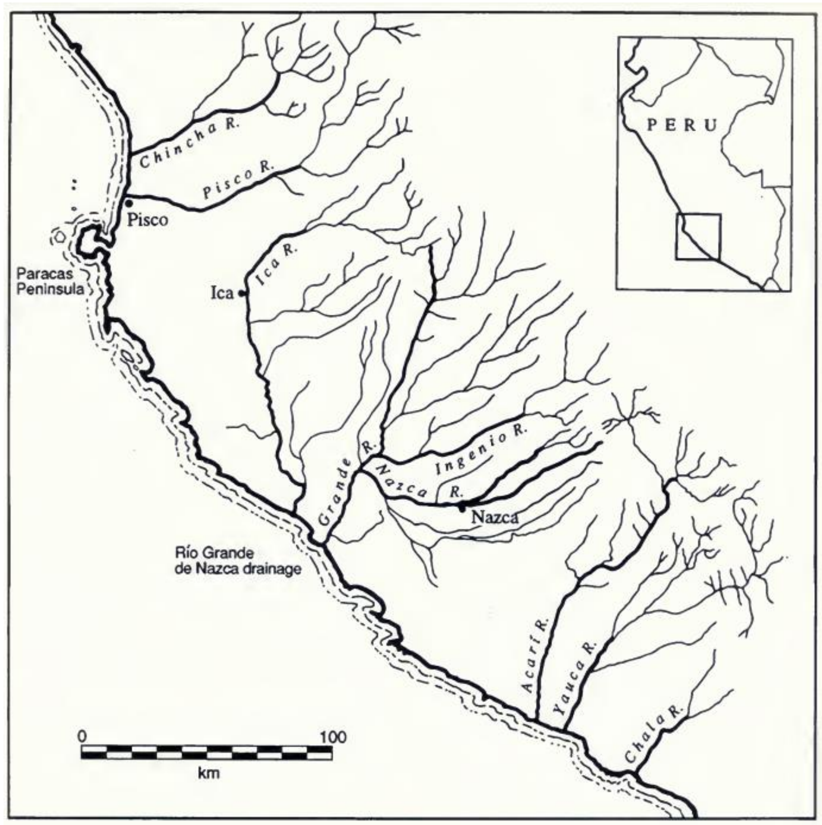


Figure 1. Map of South Coast Peru. Courtesy of Williams et al. 2001.

Previous Bioarchaeological Studies in Nasca

The emergence of bioarchaeology as a major focus of study in Peru is relatively new, beginning in the late 1970s. An analysis on human remains in archaeological contexts can increase the ability to interpret past human behavior as well as present behavior, since there are many long-enduring traditions and similar environmental factors of the region which persist to this day. The Andes in particular are a vital area to evaluate models of biological identity and mobility, patterns of health and trauma, and population dynamics (Lozada 2014). This is due to a wealth of ethnographic and ethnohistorical data that can be utilized to develop contextual frameworks for archaeological data interpretations.

The work of Julio C. Tello, a medical doctor recognized as the “father of Peruvian archaeology,” is one of the earliest examples of an interdisciplinary approach in the region. He was one of the first Peruvian scholars to study human remains from an archaeological perspective and was sensitive to the cultural interpretation of his findings (Lozada 2014). Many of his osteological studies discuss themes such as syphilis, trepanation, paleopathology, health, and disease. Tello influenced the work of Dr. Pedro Weiss, who followed his interest in the study of human remains in archaeological contexts. Weiss then became known as the “father of pathology” in Peru by identifying, describing, and characterizing native diseases linked to the prehistoric and modern Peruvian communities (Lozada 2014). Following this shift, multiple bioarchaeological studies have been conducted in Nasca over the years, focused on themes of mobility, diet, etc.

Kellner (2002) utilized archaeological cemetery data from the Tello Nasca osteological collection to analyze health impacts due to the development of complex societies in Nasca. Kellner details how the Nasca population experienced social and environmental challenges that are evident in archaeological data. Data on three prehistoric Las Trancas valley cemeteries, El Pampon, La Marcha, and Los Medanos, are used to provide skeletal evidence of health impacts due to social complexity. Kellner found that there was a great decline in enamel hypoplasia frequencies during the Late Nasca period, after a slight increase from Early to Middle Nasca periods. She observed that the Middle Horizon presented the highest level of enamel hypoplasia rates. Kellner also notes sexual differences between the enamel hypoplasia rates between males and females during these changing conditions. During the Middle Nasca period, males tended to display a lack of enamel hypoplasia. Late Nasca displayed an overall lower frequency of enamel hypoplasias. Both showed an increase in the Middle Horizon. Overall, Kellner determined that the data indicated health status deteriorated over time in Nasca.

Webb (2011) presents biogeochemical and biomolecular analyses of archaeological human and camelid tissues to investigate residential mobility, paleodiet, and antemortem stress in Nasca. The samples came from the Heinrich Ubbelohde-Doering's 1932 field season where approximately 50 Nasca-affiliated burials dating to the Early Intermediate Period and Middle Horizon were excavated (Webb 2011). Oxygen isotopic analysis revealed the individuals were likely interred at Cahuachi but originated from diverse locations. Despite this, inferences about place of residence were limited to relative comparisons in the samples, known effects of climate, topography, and hydrology on the isotopic composition of environmental and drinking water (Webb 2011). Overall, these results demonstrate the spatial breadth of the geographic origins of the individuals interred at Cahuachi, supporting the regional significance of Cahuachi as a place of burial. This can be linked to the responsiveness of populations to changing environment and socio-political conditions coinciding with a distinct Nasca cultural identity being maintained throughout the EIP.

Recently, McCool, Anderson, and Kennett (2021) performed a case study in Nasca, Peru with a focus on approaching the osteological paradox. Their goal was to evaluate morbidity and mortality patterns, risk of disease and death during the Late Intermediate Period of Nasca. Crania were examined for cribra orbitalia (porosity of the orbits) and porotic hyperostosis (porosity of the cranial vault). McCool, Anderson, and Kennett (2021) found that the orbital and vault lesions increased significantly during the Late Intermediate Period. There was decreased survivorship, lower adult life expectancy for females compared to males, and those with cranial lesions has lower survivorship across the life course. These results provide evidence for increasing physiological stress and mortality in Nasca during the Late Intermediate Period as well as substantial heterogeneity in frailty and the risk of death.

Pathology in the Andes

Diet as well as other factors are known to affect the prevalence of oral pathology in human populations. The most common oral pathologies in the Andes and Peru are dental caries, macrowear, alveolar abscess, antemortem tooth loss (AMTL), periodontal disease, and the presence of dental calculus (Gagnon 2020). The presence and extent of these conditions can be used to characterize past human biocultural experiences as they are the result of the interaction between the oral cavity and external environment. Dental caries is the most common, with diet being the essential factor. Caries are areas of localized destruction caused by the mastication of sugars which are then bacterially fermented in the mouth. Macrowear is when there is a loss in enamel or dentin on the occlusal surfaces of the teeth caused by friction during mastication. This pathology can also inform researchers on dietary composition as consumption of softer foods decreases macrowear (Gagnon 2020). When caries or macrowear exposes the living pulpal tissue in the tooth to the oral environment, this is known as an alveolar abscess. This can lead to infection, tooth death, and the compromise of the integrity of the bone itself. Calcified plaque, or calculus, is also developed from a variety of dietary and non-dietary factors (Gagnon 2020). This type of pathology can preserve DNA of the oral microbiome and has been utilized in dietary reconstruction. Lastly, periodontal disease and enamel hypoplasia can also develop due to dietary or non-dietary factors.

Watson and Muñoz Ovalle (2019) contextualized oral pathology from Middle Horizon skeletal samples in the Azapa Valley of northern Chile to record how diet was constructed and manipulated in the Andes. Despite oral hygiene practices being more difficult to reconstruct in past populations, diet composition and processing techniques can be examined from material and bioarchaeological records. Previous bioarchaeological studies have shown that subsistence practices, dietary breadth, and diet composition directly contribute to nutrition, which then impacts physiological systems and growth, and can leave skeletal markers. Six oral pathology variables were recorded in 295 individuals from nine Middle Horizon sites and compared to archaeological conditions (Watson and Muñoz Ovalle 2019). The researchers found there were no significant differences in the frequencies of oral pathologies between traditions, which suggests Tiwanaku influence may not have extended to significant changes in local diet, such as the ritual consumption of chicha. These results support models of general biological continuity in the region and are indicative of the consistency in local diet (Watson and Muñoz Ovalle 2019). Overall, this research indicates there is little evidence, at least in this sample, that diet was significantly manipulated under influences of the larger Andean population fluctuations of the time.

Bioarchaeological studies performed in the Andes have revealed evidence of cranial vault modification (CVM). There are various names for this modification: artificial cranial modification (ACD), intentional cranial modification (ICM), and cranial modification (CM). This intentional head shaping is often associated with being a significant marker of group identity over time. Group identity was argued to have provided protection, resource access, and influence beyond what an individual's family could provide in the Cuzco region but is also applicable in Nasca (Andrushko 2021). Cranial vault modification has been classified into two types: annular and tabular. Annular denotes an elongated, conical-shaped skull through circular binding with padded cushions and straps (Andrushko 2021). On the other hand, tabular characterizes an achievement of a broadened skull through compression of the frontal and occipital bones from boards and straps to cause parietal expansion (Andrushko 2021). Andrushko (2021) analyzed 419 individuals from 10 archaeological sites spanning over 2300 years, assessing for CVM using morphological analysis. Of these 419 individuals, 57 were tabular while 64 were annular. The remaining 298 did not show cranial modification. Andrushko (2021) also notes there was no significant difference of CVM between males and females in this sample. Tabular type modification appeared first and dominated the early sample (900 BC- AD 600). The Middle Horizon coincided with an influx of unmodified crania. The annular type appeared during the Late Intermediate period (Andrushko 2021). These fluctuations in CVM reveal how sociopolitical transformation impacted a highland population and practice of cranial vault modification prior to the Inca Empire.

Tung (2007) examined bioarchaeological evidence for violence during the Middle Horizon and Wari imperialism through analysis of skeletal trauma of three populations. Her study aimed at testing the hypothesis that Wari imperialism was concomitant with higher levels of violence than other pre-historic populations (Tung 2007). Three skeletal samples were utilized from Conchopata, a Wari heartland site; Beringa, a community in the Majes valley; and La Real, a mortuary site in the Majes valley. The data illuminates how the three Wari communities were affected by violent conflict, providing insight into the Wari empire and how populations were impacted by their rule. Results showed trauma between the three sites were similar indicating similar levels of violence. These frequencies were significantly greater than several other Andean skeletal populations as well. This supports the hypothesis that Wari rule was associated with much higher levels of violence. Thus, recent bioarchaeological investigation in the Andes has provided more insight into prehistoric Peruvian populations.

Knudson et al. (2017) reconstructed the lives of Wari elites using the Castillo de Huarmey excavations of 58 high-status females buried with over 1300 artifacts and six human sacrifices. The entire site "was likely constructed to legitimate the new political power wielded by the Wari elite in the Huarmey Valley," (Knudson et al. 2017). Osteological and paleopathological analyses suggest these females lived a life almost free of physiological stress, illness, and major trauma. Radiogenic strontium isotope data show no clear cases of first-generation migrants from the Wari heartland. The data suggests these individuals may be second- or third-generation migrants (Knudson et al. 2017). This lack of first-generation migrants from other parts of the Andes reflects the importance of multi-generational settlements at Wari-affiliated provincial sites. The site of Conchopata was the secondary center in the heartland of the Wari empire. Radiogenic strontium isotope analysis revealed this site was not a cosmopolitan center, rather it was populated by local peoples (Tung and Knudson 2011). A young female was found which suggests captive sacrifices as the individual was interred in front of a ritual D shaped structure. These multiple examples of archaeological evidence support the notion that the Wari occasionally used militaristic means along with ritualism to subjugate other populations, a tactic which helped Wari establish and keep control over the Andes.

2.2 Nasca Status Differentiation

Cranial Vault Modification and Linkage to Status

Humans often distinguish themselves from others through bodily modification, usually demarcating a group cohesion within society. By creating distinct differences that are not present at birth and giving meaning to these differences, culturally constructed and symbolic boundaries are created (Blom 2005). Permanently modified crania are not only an aesthetic feature in the Andean region; but the process of cranial vault modification (CVM) also conveys social information. Due to the malleability of the skull during infancy, cranial vault modification must be performed at this age (until 3-5 years old). Subsequently, cranial modification is not associated with rites of passage and thus contrasts with other forms of known body modification that mark important social and age transitions. Distinct regional patterns are clear in the way in which head form was modified (Blom 2005). Certain forms of cranial modification are characteristic of different valleys, such as solely fronto-occipital modification for the Moquegua valley. Since the skull must be molded early in childhood, modified head shape is thus a lifelong cultural imposition on societal members. Cranial modification is a permanent symbol of ascribed identity or acquired/aspired identity of one's elders (Blom 2005). CVM would be quite dramatic and noticeable to foreign individuals and these highly visible cues are utilized in exchanging information and marking group and/or ethnic boundaries. In comparison to other identifying factors such as clothing, cranial modification is not flexible and cannot be altered throughout the life course.

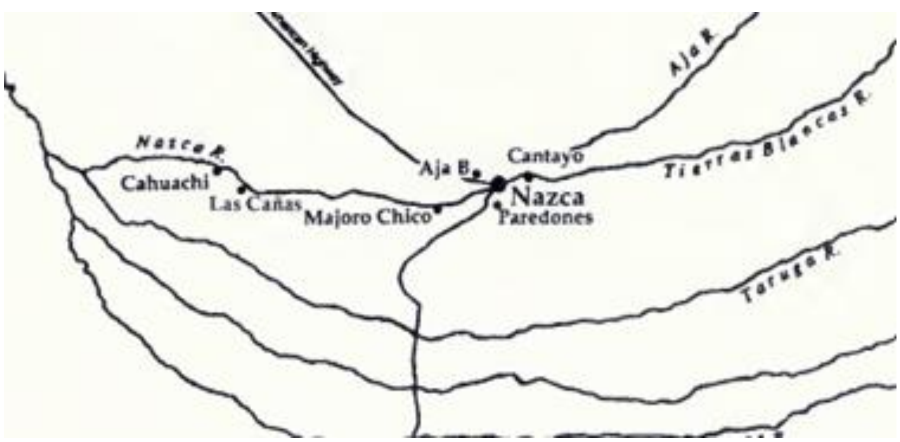
Torres-Rouff (2002) aimed to better understand the implications of CVM in reference to the supposed forced interactions of the Tiwanaku and San Pedro de Atacama peoples. "My working hypothesis was that the rise in Tiwanaku influence on the Atacama culture should be reflected in an augmentation of the complexity of the symbolic systems used to maintain social boundaries between segments of the population," (Torres-Rouff 2002, 165). This growth in interaction may have led to an increase in the elaborateness of the practice of cranial modification in the region as evidenced through varying forms of modification. Torres-Rouff (2002) analyzed CVM from two sites, 99 crania from Toconao Oriente (100 B.C.-A.D. 300) and 92 crania from Solcor (A.D. 400-900). Archaeological evidence in this region suggests that access to wealth and the complexity of local material culture increased with Tiwanaku contact.

In contrast to their hypothesis, Torres-Rouff (2002) concluded that the frequencies of modified skulls at Toconao Oriente and Solcor did not differ significantly. This result would indicate that the prevalence of cranial modification did not vary markedly though time in this area. Torres-Rouff (2002) also noted CVM ratios between males and females and found these too did not vary significantly. This would suggest that a desire to mark gender-based differences was not a determining factor in the decision for cranial vault modification.

In various archaeological studies in the Andes, cranial modification has been found to be equally carried out between men and women (Gerszten 1993; Torres-Rouff 2002; Gomez-Mejia et al. 2022). It is often found to be a significant cultural artifact to serve as a territory marker or social boundary, to reaffirm ethnicity, and maintain and strengthen exchange networks (Gerszten 1993). Ethnic affiliation, resource access, economic specialization, and social status are easily displayed by bodily appearances. Previous studies, not from Nasca, have revealed that CVM is not necessarily linked to hierarchical/wealth status, but more associated with social status/identity (Gomez-Mejia 2022). However, Blom (2005) refers to de las Casas (1892) who stated that the Inca distinguished themselves from the "lower classes" by artificially elongating their skulls. Differences in cranial modification in the same area may be linked to individuals coming from different areas, especially in the cases of marriage, kidnapping, etc. The individuals who had different modification styles were brought into a community with their shaped heads remaining a permanent indicator of their foreign origin. While the exact meaning and type of cranial modification varies throughout time and the region, it was a major social identifier in the ancient Andes.

Nasca Trophy Heads: Purpose and Usage

Trophy head taking is defined as: "an organized, coherent form of violence in which the severed head is given a specific ritual meaning and the act of head taking is consecrated and commemorated in some form," (Kellner 2002). Among archaeologists, there have been various explanations for trophy head accumulation. Browne et al. (1993) mentions the considerable debate over the appropriateness of the "trophy-head" label for Nasca severed heads. The debate mainly centers on whether the heads were obtained as memorabilia of ritual practices or trophies of war. In my study, comparing measures of health status with evidence of trophy heads and/or cranial modification aids in the interpretation of how dental health and sex disparities are correlated. Depending on the associated skeletal markers of an individual, health status can be interpreted and therefore presence or absence of linear enamel hypoplasia will provide evidence of how those of certain status were impacted by stress. Trophy heads and ceramics are often evidence of status in burial contexts. Evidence of trophy heads often indicate success in warfare, which is correlated to prestige and power in society for those who collected the heads.



Map 2. Map of sites where trophy heads were found. Courtesy of Williams et al. 2001

Williams et al. (2001) performed an osteological study on Nasca trophy heads collected by A.L. Kroeber during the Marshall Field Expeditions to Peru. Kroeber's expedition recovered 18 trophy heads during the 1925 and 1926 Marshall Field Expeditions. 14 adults, two subadults, and two children were recovered. Out of these 18 individuals, eight were young men, two were female, and the rest were undetermined (Williams et al. 2001). Ten of the trophy heads were recovered from Cahuachi. Dates of these heads range from the Early Intermediate Period to the Middle Horizon. Two trophy heads were recovered from Cantayo and are from the Early Intermediate Period. The last two trophy heads were recovered from Majoro Chico, dating to the Early Intermediate Period as well. While Williams et al. (2001) does note evident pathology and dental characteristics, such as periodontal disease presence and antemortem tooth loss, they do not make note of evidence of linear enamel hypoplasia. Evidence or lack of linear enamel hypoplasia would aid in understanding the correlation of experienced stress and sex, especially when not all the trophy heads are male. The sex of individuals who became trophy heads has also been used to question the reason and purpose for head-taking since not all trophy heads were from males.

"Clearly, in late Nasca times, warfare and trophy headhunting were important activities. Real caches of trophy heads are known, and elite men self-portrayed their position of status through fine garments and the possession of trophy heads," (Silverman & Proulx 2008: 236). It is also likely the heads were collected as warfare trophies and then used in rituals as proposed by Proulx (2008). Lastly, due to the available archaeological evidence of head-taking, it is also possible to have multiple meanings and purposes. As shifts occurred in the Andes and Nasca, the role and meaning of trophy heads in Nasca practice and ideology may have also shifted. A diagnostic trait of a Nasca trophy head is the hole drilled on the frontal bone through which a cord is often threated so it may be displayed (Tung 2008). The location and size of the hole vary. The hole may be placed anywhere from between the orbits to higher on the frontal bone, towards the coronal suture. Tung's (2008) analysis on Conchopata trophy heads from Ayacucho, near Wari, analyzed these intentionally drilled perforations. A hole drilled into the superior of the cranium allows for it to be suspended so that the face looks forward (Tung 2008). This is a characteristic which appears to be intentional through the engineering design and was standard throughout Wari individuals. Nasca trophy heads, however, show holes placed variably on the frontal bone. This may display a different cultural preference since Wari is in the highlands in Ayacucho.

How Burial and Funerary Contexts Are Linked to Nasca Status

Archaeologists have used cemetery data to reconstruct social organization and sociopolitical complexity with consideration of symbolic aspects of mortuary contexts (Silverman 2019). The Nasca peoples generally entombed their dead in cemeteries. "Most bodies are found in a seated, flexed position, usually enshrouded in one or more textiles and accompanied by burial objects," (DeLeonardis 2000). Even in instances of status differentiation, people are typically accompanied by grave goods whether it be cloth, ceramics, trophy heads, etc. Carmichael (1988) remarks on how mortuary theory details how the treatment granted to an individual in death is taken as a reflection of his/her position in life. An elaborate burial may be viewed as an indication of an individual's status; however, it is only when a substantial number of similar burials have been identified that the term "rank" is applied. Proulx (2001) mentions from the Nasca burials scientifically recorded, a graded continuum from simple to more elaborate graves support this presence of a ranked rather than stratified society.

Robb et al. (2001) describe three premises in establishing a relationship between health and status. Premise 1 is the society was stratified by those whose lifestyles differed in terms of nutrition, health, or stress. If this is not the case, higher and lower classes would be skeletally homogeneous despite differences. Premise two is “elite and commoner burials can be distinguished through archaeological evidence such as grave goods,” (Robb et al. 2001). The final premise in their comparison is the health and well-being of the living can be distinguished through skeletal markers in the dead. These three premises offer insight into comparing funerary treatment and skeletal biology with correlation to social status. In this regard, Carmichael (1988) analyzed Nasca mortuary customs with a focus on material remains and status. Nonceramic grave goods are mentioned to not be especially useful status indicators but are noted. Weapons are generally associated with individuals of mid-high status. Logs, timbers, and other textiles are correlated to those of high status. Being rare, metal is also associated with status: copper with mid status, gold with high status. Ceramics, as Carmichael (1988) notes, do not provide a direct measure of status alone, but may serve as status markers when accompanied by other goods. Vessel pairs, however, are noted to be associated with mid to high status individuals. Trophy heads are also documented in Carmichael’s examination. Typically, burials which contain trophy heads are “special” in one sense or another. These heads are not directly related to status but rather are an indication of special circumstances surrounding the individual they accompany. “As the product of human behavior, the funerary domain is multi-dimensional in terms of social and corresponding material expression,” (Carmichael 1988). It is important to note material remains linking burial context with status will not be present for every society and that cultural factors may impact this record. Not all status treatments may be visible in the archaeological record depending on the region, time, culture, and other characteristics. Songs, speeches, attendance of the funeral itself, decomposition of materials, and other factors are not preserved in the archaeological record and therefore cannot be directly used to interpret status.

2.3 Stress Pathology

Linear Enamel Hypoplasia: The Connection Between Stress, Status, and Linear Enamel Hypoplasia

As one of the toughest substances within the human body, tooth enamel is extremely durable and damage resistant and is thus easily preserved, even in prehistoric individuals. Importantly, analysis of enamel hypoplasia and their implications can provide insight into adaptations and stress of the past. Enamel defects provide a sensitive but nonspecific response to a variety of factors. Developmental defects in the enamel often represent stress-induced disruptions in growth. Stress has been defined as a stereotypic physiological reaction to environmental insult (Duray 1996). These enamel defects provide a record of such stress due to enamel being unable to remodel after being affected (Goodman & Rose 1990). When an individual experiences stress such as malnutrition, trauma, etc. at an early age, it can cause a temporary pause in amelogenesis (enamel formation) to focus bodily production and homeostasis on other regions of the body (Nikita 2017). When the stress is over, amelogenesis begins again, resulting in an enamel defect marking the disruption in the dentition.

Health, diet, and socioeconomic status can impact the development of enamel defects. "Abnormal tooth formation is a generally nonspecific phenomenon and can be related to a variety of local and systemic disturbances," (Hillson 2013, 166). Systemic factors tend to target the first permanent molars and incisors, while local factors impact the permanent maxillary incisors and upper/lower premolars (Kanchan et al., 2015). In combining health, diet, and socioeconomic status and local and systemic factors impacting dentition, Saunders and

Keenleyside (1999) found there is an increase in LEH levels with agricultural intensification. Those of higher status obtain better access to resources, have better health, and experience lighter workloads.

Hypoplasia has also been located on children who had rickets, scurvy, measles, smallpox, and other illnesses (Hillson 2013; Nikiforuk et al. 1981; Kanchan et al. 2015). In correlation to the development of diseases, a link between enamel defects and vitamin A and D deficiencies have also been found. Populations exposed to a high degree of malnutrition, whether prehistoric or contemporary, share increased rates of linear enamel hypoplasia (Goodman & Rose 1990, 60; Hassett 2013, 463; Hillson 2013, 171). Linear enamel hypoplasia has also been present in children reported to have had acute diarrheal disease. This disease is caused by malnutrition, which is reflected in hypocalcemia and in turn, results in LEH (Nikiforuk et al. 1981). When an individual experiences stress such as malnutrition or disease, the body reacts in diverse ways in order to keep homeostasis and survive. In these efforts, enamel production is postponed until the individual recovers from the stress to help the body focus attention on other bodily processes. Once the individual recovers, the body can redirect focus back to enamel production, resulting in defects in the dentition from the pause. Deeper and wider linear enamel hypoplasia defects are typically linked to more severe events, while smaller defects represent shorter durations of stress.

Enamel hypoplasia has been used to examine metabolic disruptions experienced during early childhood. “The first few years of life are a time of rapid growth when nutritional needs are high and infants and children are particularly vulnerable to environmental stressors,” (Malville 1997, 351). During early childhood, infants and children have low resistance to disease, many of which affect nutritional status. This change in nutritional status among children can then impact enamel formation. Defects within deciduous teeth are indicators of the physical and nutritional status of the mother (Lovell &Whyte 1999). Deciduous teeth are formed in utero; therefore, the status of the mother can impact the fetus. After birth, Lovell, and Whyte (1999) acknowledge the impact weaning has on the stress of infants. The immune system does not mature until about two years of age in humans. Passive immunity is obtained from the mother through nursing, which reduces the risks of illness. However, weaning early may cause stress on the child and decrease the immunity they have to illnesses, increasing the risk of EH.

A focus on linear enamel hypoplasia shows it is primarily due to generalized systemic stress, oftentimes by infectious disease, nutritional stress, or a combination of those. Evidence of LEH may aid in identifying sex-specific stressors during childhood. However, sex differences in LEH have not been fully addressed, and most literature lacks a critical evaluation (Guatelli-Steinberg & Lukacs 1999). Recent investigations that have examined the correlation between enamel hypoplasia etiology and sex have found varying results. Oyamada et. al (2012) describes how research in various early modern Japanese countries have produced contradictory results: higher prevalence in females, males, or no significant difference between sexes. "Enamel Hypoplasia frequencies are commonly compared to those in modern populations, to determine the relative childhood health status of a population," (Griffin & Donlon 2009, 93). Griffon and Donlon (2009) discovered a broad correlation between childhood stress and sex in two archaeological sites in Jordan while analyzing enamel defects. Griffin and Donlon (2009) identify females as having a higher prevalence in enamel hypoplasia per tooth. In this case, the correlation between EH and females is due to genetic and environmental factors. Socioeconomic status, malnutrition, infectious disease, weaning, and premature birth are factors.

King, Humphrey, and Hillson (2005) also found females to have greater numbers of LEH, along with shorter intervals between defects than males in postmedieval London. "This could indicate either those female children experienced greater physiological stress than male children as a result of differential treatment, or it may reflect similar levels of exposure resulting in higher mortality in males and a higher frequency of LEH among female survivors," (King, Humphrey, & Hillson 2005, 558). Various stressors can impact the prevalence of LEH in males and females, however survivability may also be a factor. A higher mortality can affect the development of enamel defects, causing a differentiation between sexes even if they experience similar amounts of stress. Nutritional availability may also play a role in enamel defect formation (King, Humphrey, & Hillson 2005). Per the society and culture of an area, a priority on a specific sex may lead to different stressors. When males or females are more prioritized and have easier access to resources, stress is lower in those individuals, affecting EH development.

An analysis of Late Medieval populations in Croatia between the 14th and 18th centuries shows comparable results to King, Humphrey, & Hillson (2005). "These differences often follow the same pattern with females exhibiting higher frequencies of deaths, relative to males, during late adolescent and early adult years," (Slaus 2000, 194). An increase in female mortality is often associated with neonatal mortality due to pregnancy complications and childbirth risks. However, within this sample, adult females displayed more hypoplasia than males. The significant difference in frequencies of EH suggest females experienced higher subadult stress. The correlation between high female mortality and high female EH may refer to shorter life spans or extreme stress. This could also mean the assumption of high female mortality is incorrect and females survived longer while experiencing high stress, developing more enamel hypoplasias.

Goodman, Armelagos, and Rose (1980) also address whether there is a different frequency of growth disruptions by sex. In the prehistoric populations from Illinois, enamel hypoplasia was more noticeable in females, but it was not statistically significant. They acknowledge there was no clear pattern of differences by sex (Goodman, Armelagos, and Rose 1980). This was expected as arguments for either males or females having more growth disruptions can be made. Growing males tend to be more sensitive to stress while females are often less culturally buffered from stress. May, Goodman, and Meindl (1993) analyze enamel formation in malnourished Guatemalan children. "The high prevalence of enamel hypoplasias in individuals of low socioeconomic status is often attributed to their inadequate nutrition," (May et al. 1993, 38). In this study, females displayed a higher prevalence for hypoplasia than males. This could be attributed to females in this society having a lower socioeconomic status and thus, inadequate nutrition compared to males.

Similarly, in early modern Japan, females were considered inferior, causing them to be subject to deprivation during childhood. "In a society that favors males, one might expect to find more evidence of stress in the teeth of females than of males, indicating the preferential treatment of males in child-rearing," (Oyamada et al. 2012, 97). This study analyzed line and groove LEH and when combined, females had a significantly higher prevalence. "Sex differences in the prevalence of LEH have been attributed to various factors, including sex differences in susceptibility to stress and discriminatory allocation of nutritional and medical resources in favor of male offspring," (Oyamada et al. 2012, 100). Differential treatment in childhood led to differences in LEH development as a focus on male heirs caused a devaluation on female children.

In contrast, males sometimes display more enamel defects than females. Saunders and Keenleyside (1999) macroscopically examined enamel defects in a Canadian historic sample. The authors found the enamel hypoplasia to be more prevalent in males, especially in the maxillary and mandibular canines. The occurrence of these defects can be higher in males due to reported sex bias in stress susceptibility as well. Lovell and Whyte (1999) examined dental enamel defects in ancient Maledes, Egypt. “These results must be considered tentative, since only half of the skeletal sample could be assigned a sex, but they are in accord with textual accounts of child welfare in ancient Egypt,” (Lovell & Whyte 1999, 78). Examination of the dental defects and textual accounts leaned towards males exhibiting more enamel hypoplasia than females. Again, however, the difference in enamel defects was not statistically significant between sex despite males having more. Guatelli-Steinberg and Lukacs (1999) analyzed sex differences in enamel hypoplasia as well. They acknowledge how when sex differences are significant, there is a slight trend for them to be greater in males. This would go to suggest a weak influence of greater male vulnerability.

> “If indeed males are biologically less well buffered than females and are more susceptible to fluctuations in environmental variation, then under various conditions that theoretically ‘stress’ homeostatic biological systems, males would be predicted to more frequently retain markers of stressful events,” (Guatelli-Steinberg & Lukacs 1999, 87).

These authors argue for males exhibiting higher enamel hypoplasia frequencies as males are expected to be associated with increased levels of environmental stress. Overall, Guatelli-Steinberg and Lukacs detail that if males are biologically more susceptible to fluctuations in environmental variation, then certain conditions would cause increased stress. This increased stress would then make males more prone to retain markers of stressful events.

Studies can also reveal no clear statistical differences between enamel hypoplasias on males or females. Temple (2008) investigated the correlation between sex, stature, and enamel hypoplasia prevalence in premodern Japan. Focusing on the correlation of sex and LEH, Temple found this to be insignificant. Both locations from Japan analyzed demonstrated no prevalence of LEH between sexes. In addition to Temple (2008), Lanphear (1990) found equivalent results when examining dental enamel hypoplasias. “Dental enamel hypoplasias may be considered to be indicators of increased exposure to health risk at the time of weaning,” (Lanphear 1990, 35). Weaning can cause an increased amount of stress for an infant due to a lack of passive immunity from the mother and being exposed to new sources of infection through their newly introduced diet. However, this increased exposure was not prevalent in one sex over the other. No statistically significant differences in the presence of hypoplasias between males and females were found. Overall, evidence of enamel hypoplasias can be contradictory in that there is a higher prevalence in females, males or there simply is not significant difference between sexes.

Linear Enamel Hypoplasia Studies in Peru and Nasca

Klaus (2020) examined metabolic diseases within Andean paleopathology and specifically focused on LEH. “Of all the skeletal reflections of metabolic disruptions, defects of tooth enamel are perhaps the best understood and most widely studied in paleopathology and bioarchaeology,” (Klaus 2020, 54). An examination of the distribution and record of linear enamel hypoplasias, porotic hyperostosis, scurvy, and rickets help provide more information on the health within the Andes. Klaus noted that documentation of enamel hypoplasia in the early modern Andes was uneven and underdeveloped as enamel defects were not often included in skeletal indicators of biological stress. Enamel hypoplasia were typically utilized for frequency data or employed as a supporting actor for other stress indicators. “Increasing frequencies of enamel hypoplasia are noted as sedentary agricultural economies intensify, population sizes grow, and as social complexity increases,” (Klaus 2020, 56). A focus on the Moche culture on the north coast revealed a ranked, hierarchical society. A bifurcation of enamel hypoplasia was found showing it was rare among high-status or elite members but common among lower status peoples. Klaus noted prevalence rates are generally low among the south coast populations in the

Andes. This would go to suggest effective buffering mechanisms against childhood metabolic stress in the hyper-arid region of the Andes. “Enamel defect patterns, further informed by elements of social epidemiology and embodiment theories, have been useful in certain interpretive and problem-solving situations, such as the question of sacrifice victim identity,” (Klaus 2020, 60). Enamel defects and other pieces of skeletal evidence allowed researchers to understand the biological embodiment of lower social status peoples. Also, on the north coast of Peru, a vast majority of skeletal indicators demonstrate a clear indigenous biological stress. However, enamel defect prevalence was much lower in the post-contact sites of Morrope, Eten, and Magdalena da Cao. Lima had no differences in enamel defects between pre- or post-contact samples (Klaus 2020). An explanation could be the osteological paradox, explained further later in this review. An increased subadult frailty and high mortality would explain children dying before enamel defects even formed on the dentition.

Klaus and Tam (2009) performed an examination on the systemic stress in colonial Morrope, Peru. The authors were testing the consequences of Spanish colonization and whether it caused the population of Morrope to experience elevated systemic biological stress. A significant decrease in linear enamel hypoplasia prevalence may not indicate improved health but reflect effects of high-mortality epidemic disease (Klaus and Tam 2009). Macroscopic observations revealed the overall prevalence of linear enamel hypoplasia decreased and was 1.8 times less common during post-contact Morrope. “This pattern is the effect of a trend of decreasing linear enamel hypoplasia prevalence initiated in the Early/Middle Colonial period that continues into Middle/Late Colonial times,” (Klaus and Tam 2009, 361). Some explanations for this decrease in linear enamel hypoplasia post-contact have been provided. The authors provide four possible reasons: (1) some currently undetected sampling bias might have skewed the representation; (2) Morrope could have experienced rapid selection and adaptive process, however this is inconsistent with the declining health of the population at the time; (3) post-contact acute stress could have been of shorter duration or lessened severity and did not produce LEH; or (4) acute childhood stress could have shifted from survivable insults to high-mortality infection. No matter which reason is correct, Morrope experienced a decrease in linear enamel hypoplasia post-contact. The authors did not discuss a focus on sex of the individuals, especially since many were children.

Lacerte (2019) examined the central coast of Peru for enamel defects predominantly from the Inca Period. A small sample of 10 adult females, 11 adult males, and five adolescents of indeterminate sex were used. Lacerte (2019) utilized a Scanning Electron Microscopy in this study. This device increases visibility of linear defects to determine frequency, age, and duration that the metabolic disruption affected the enamel growth. Lacerte also used macroscopic methods for studying visible enamel defects on the dentition. A hand-held magnifying device aided in determining the distance from the cemento-enamel junction to the occlusal wall of a defect, using calipers to measure said distance. "Chicha production is another cultural factor that has the potential to impact health, particularly among women, who prepared maize for fermentation by masticating it into a paste," (Lacerte 2019, 33). Despite this analysis, there was no statistical significance between male and female LEH, however Lacerte acknowledges the sample size was too small to make a quantifiable determination.

Specifically looking at Nasca, Kellner (2002) investigated three prehistoric Las Trancas valley cemeteries, El Pampon, La Marcha, and Los Medanos to provide skeletal evidence of health impacts due to social complexity. Environmental and political changes occurring at the time was detrimental to the health of the Nasca population. Following the timeline, there was a slight increase in enamel hypoplasia frequency from the Early to Middle Nasca periods then a sharp decline in the Late Nasca period. Kellner (2002) observed the highest level of enamel hypoplasia rates during the Middle Horizon which correlates to Wari imperialism. There are some sexual differences between enamel hypoplasia rates between males and females as well. Middle Nasca period males tended to have less than females. Overall, Late Nasca displayed a lower frequency with both males and females. Both sexes showed an increase in the Middle Horizon.

Osteological Paradox

The osteological paradox revolves around three problems confounding statistical interpretation of prehistoric health from skeletal samples: demographic nonstationarity, selective mortality, and unmeasured, individual level heterogeneity in the risks of death and disease (Wood et al. 1992). Demographic nonstationarity refers to the departure of a population from a stationary state. Changes in fertility greatly impact age-at-death distributions, but not changes in mortality. Thus, increased fertility both increases the overall population and therefore, the potential population who may die and enter the skeletal record. This may appear like more people died to bioarcheologists, but proportionately rates of death may have in fact stayed the same.

Selective mortality refers to the lack of a sample of individuals who were at risk of disease or death at a certain age. Samples are of those who died at a given age, not those at risk. “Common sense suggests that there should be some reasonably direct association between aggregate-level measures and the risks of illness and death experienced by the individual members of past populations,” (Wood et al. 1992, 343). The presence of healed lesions on the skeleton are perhaps evidence of lower frailty and lower risk of death rather than indicators of those who were most sick since these lesions take time to appear. Due to their superior condition and health status, the individual was able to survive long enough for the healed lesion to manifest. Conversely, those without lesions may have actually been less resilient and sicker, succumbing to death before lesions could heal. In occurrences of linear enamel hypoplasia, this is especially important as the presence of the lesion can signify an experienced stress, but also forms after the survival of said stress. Individuals who present fewer or no enamel lesions may have thus experienced less stress *or* possibly died before the lesions could manifest.

CHAPTER 3: MATERIALS AND METHODS

3.1 Skeletal Sample

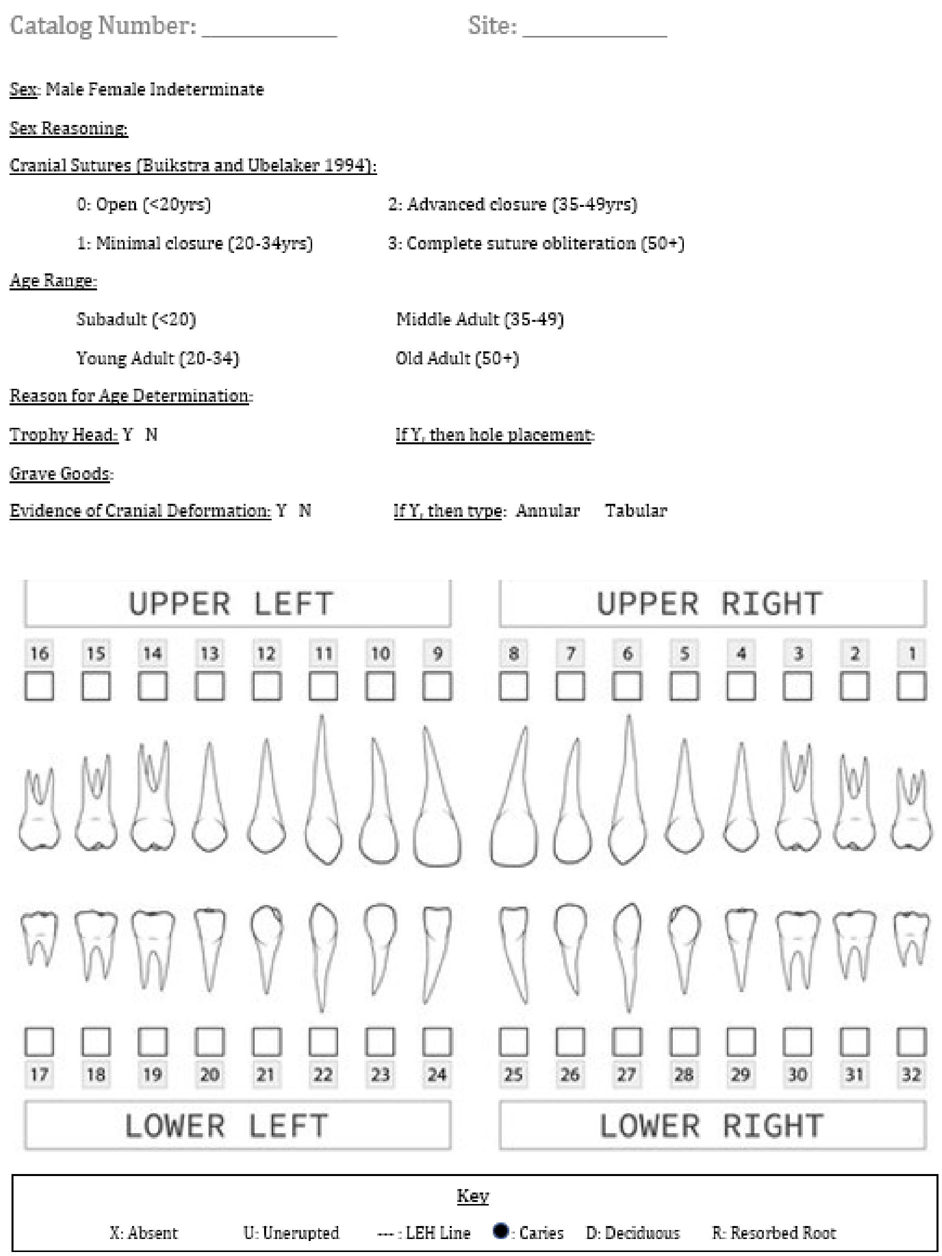
Kroeber Nasca Skeletal Collection at the Field Museum

The skeletal material selected for study is from the Kroeber Nasca skeletal collection residing at the Field Museum in Chicago, Illinois. I analyzed 47 crania from the collection. The majority of the Nasca crania were collected from the First and Second Marshall Field Expeditions conducted by Kroeber and colleagues between 1925 and 1926. The Nasca sample is predominantly from seven sites spread between the Early Intermediate stages: Early Nasca, Transitional or Late Nasca, and the Middle Horizon. Dentition availability was varied per individual due to environmental impacts, burial type, normal degradation, and other influences. Due to typical anterior tooth loss, this study primarily focused on the buccal teeth. This selection includes the premolars (P1 and P2) and the molars (M1, M2, and M3 if available). If anterior dentition such as canines, central and lateral incisors were available, they were documented as well.

In Kroeber's archaeological excavations, 18 trophy heads were discovered during the Marshall Field Expeditions. These trophy heads dated from the Early Intermediate Period to the Late Intermediate Period. The trophy heads correlating to this study's chronological focus (11) were analyzed for indicators of linear enamel hypoplasia as well. The trophy heads dating from the EIP to the Middle Horizon were analyzed and these heads were specifically from the sites of Cahuachi, Cantayo, and Majoro Chico.

3.2 Data Collection

The data collection for my study included documentation of catalog number and associated site as seen in Figure 2. Estimated sex and age for each of the 47 individuals as well as reasonings for those estimations were documented. Some of the individuals in this sample already had estimated sex and age documented through the Field Museum and I compared my estimations to those made previously. Presence/absence of trophy heads and if applicable, location of frontal perforation was listed. Evidence of cranial modification was also documented if observed. Figure 2 also shows a dental chart and key which were utilized to document dentition and evident linear enamel hypoplasia.



Catalog Number: ____________ Site: ____________

Sex: Male Female Indeterminate

Sex Reasoning:

Cranial Sutures (Buikstra and Ubelaker 1994):

0: Open (<20yrs) 2: Advanced closure (35-49yrs)

1: Minimal closure (20-34yrs) 3: Complete suture obliteration (50+)

Age Range:

Subadult (<20) Middle Adult (35-49)

Young Adult (20-34) Old Adult (50+)

Reason for Age Determination:

Trophy Head: Y N If Y, then hole placement:

Grave Goods:

Evidence of Cranial Deformation: Y N If Y, then type: Annular Tabular

Key

X: Absent U: Unerupted --- : LEH Line ●: Caries D: Deciduous R: Resorbed Root

Figure 2. Data collection chart utilized in this study.

Age Estimation

Age is a principal factor in analyzing linear enamel hypoplasia. Linear enamel hypoplasia can only be formed during deciduous and permanent tooth development. Once the permanent dentition has completed eruption and formation of all teeth around 21 to 25 years of age, enamel production ceases. Thus, the stress which caused LEH to form on these individuals must have been experienced during infancy to adolescence or early adulthood. Instances of LEH past these early ages and into middle and older adulthood present information on the past health status of these individuals.

Many characteristics of the human skeleton can be utilized to estimate age of the individual. However, due to the lack of availability of postcranial remains, the crania were the sole focus of analysis. I followed Buikstra and Ubelaker's (1994) method of age estimation, which focuses on the distinct stages of cranial suture closer. In early infancy, the bones which make up the skull are not fully fused together. As an individual ages, the bones gradually fuse together until they are completely obliterated and fully fused. Through various analyses, Buikstra and Ubelaker (1994) developed a method of age estimation using the level of cranial suture obliteration, as described in Table 2.

Suture Closure Type	**Age Estimation in Years**	**Age Group**
Open	< 20 Years	Subadult
Minimal Closure	20-34 Years	Young Adult
Advanced Closer	35-49 Years	Middle Adult
Complete Suture Obliteration	50+ Years	Old Adult

Table 2. Buikstra & Ubelaker (1994) Model of Age Estimation Based on Cranial Sutures

Sex Estimation

Regarding the comparisons of linear enamel hypoplasia between sex, age is a primary focus in this project as well. Sex estimation in subadults is not reliable and produces many instances of indeterminate estimations. Before the influx of the hormones estrogen and testosterone during puberty, subadults do not display the characteristics utilized in sex estimation. For this research project, visible/macroscopic methods were used instead of metric methods. The pelvis and the skull are the two primary features utilized in sex estimation. Due to archaeological excavation, environmental degradation, and other wear on the remains, sex estimation was determined from only the crania, as many postcranial remains were lacking or not available at all. Due to unavailability of postcranial remains, pelvic examinations were not used in this study, but will be defined briefly. Three key features are analyzed when using the pelvis: ventral arc, subpubic concavity, and medial aspect of the ischiopubic ramus (Langley 2017). The ventral arc is more present and pronounced in females, while absent in males. Similarly, the subpubic concavity of the ischiopubic ramus is more present and pronounced in females and absent in males. The medial aspect of the ischiopubic ramus is often sharper and narrower in females while dull and wide in males.

For the skull, the nuchal crest ranges from smooth (female) to a large projection of bone (male). The mastoid process ranges from very small (female) to larger and wider (male). Males tend to have thick and rounded orbital margins while females tend to have extremely sharp orbital margins (Langley 2017). Females typically display little or no projection in the glabellar supra-orbital ridge. Males on the other hand present massive glabellar areas. Lastly, the mental eminence is utilized in sex estimation. Females tend to present a smooth mental eminence and males present a large projection on the mandible. The features used from the skull and pelvis for sex estimation are areas of predominant muscle attachment. This muscle attachment does not become differentiated between sex until after puberty, when there is a prevalence of estrogen and testosterone between individuals (Langley 2017). Thus, for this sample I classified adult individuals into five categories: male, female, probable male, probable female or indeterminate.

Cranial Modification Presence or Absence

Figure 3. © Courtesy of The Field Museum, Cat. No. 171163, Photographer Elizabeth Moore.
Older adult female from Early Nasca Period in Cahuachi with evident cranial modification.

Figure 4. © Courtesy of The Field Museum, Cat. No. 170521, Photographer Elizabeth Moore. Young adult female from Early Nasca Period in Majoro Chico with evident cranial modification.

Cranial vault modification (CVM) was an important socio-cultural phenomenon within the ancient Andes. This bodily modification was noted as present/absent for each of the 47 individuals in the sample. If evident and able to be determined through personal observation, I noted the specification of type of modification. Individuals displaying frontal flattening, parietal expansion, or other examples were documented. However, focus was primarily placed on only the presence or absence of cranial modification as many of the crania were fragmented and unable to be distinguished in terms of CVM type.

Trophy Head Presence or Absence

Figure 5. © Courtesy of The Field Museum, Cat. No. 171008, Photographer Elizabeth Moore. Young adult female trophy head from Early Nasca Period in Cantayo.

Figure 6. © Courtesy of The Field Museum, Cat. No. 171099, Photographer Elizabeth Moore. Young adult indeterminate trophy head from Middle Horizon Cahuachi.

Trophy heads were a common occurrence in Nasca, especially between the Early Intermediate Period and Middle Horizon. A specific trait of a Nasca trophy head is a hole drilled through the frontal bone in which a cord would often be threaded for it to be displayed (Tung 2008). Depending on the culture, the location of the hole varied, though it was most likely anywhere between the orbits to towards the coronal suture. Before Wari takeover, the Nasca culture often displayed varied locations for perforations in the frontal bone. However, the Wari appears to have standardized the trophy head process by intentionally drilling a hole into the superior part of the frontal bone so that when suspended, the face looks forward (Tung 2008). For this study specifically, trophy head presence or absence was documented for every individual. The trophy heads present in this sample had already been determined based on excavation data (Williams et al. 2001). If present, the frontal perforation placement was documented.

Linear Enamel Hypoplasia Examination Methodology

To measure prevalence and severity of linear enamel hypoplasia, a dental chart was utilized in this study abiding by the Universal Numbering System (1-32) (Hillson 2013).

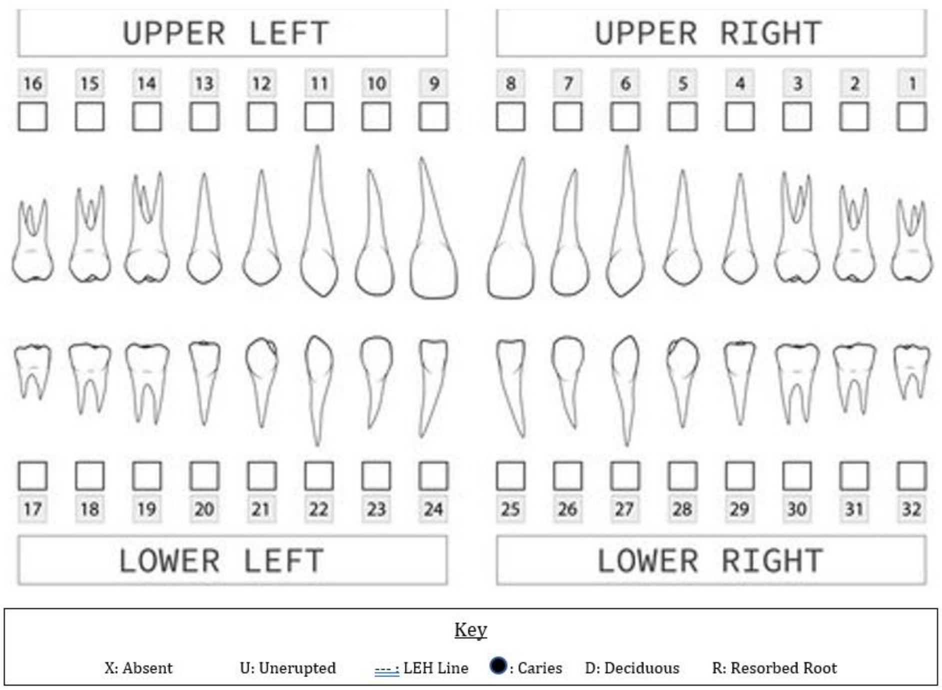


Figure 7. Dental Chart and Key utilized in this study per individual.

Macroscopic observation was conducted by counting every line (1-3) of linear enamel hypoplasia per tooth per individual. These lines were then drawn on the corresponding tooth on the dental chart to denote LEH presence and severity. Other dental characteristics were documented as well. Antemortem and perimortem tooth loss were documented. Resorption of mandible and maxilla were documented as well. If present, carious lesions were documented with the corresponding dentition. Due to time, degradation, storage, the environment, and other factors, there was severe postmortem tooth loss which was documented. However, for some individuals, not in situ teeth were kept separate and were documented for placement and LEH presence. Some subadult individuals still had unerupted or deciduous dentition which was noted as well. Largely in this sample, there were instances of extreme dental wear which occurred antemortem. Dental breakage was also prevalent, though the majority occurred postmortem. Tooth loss, antemortem and postmortem, resorption, wear, and breakage were inhibiting factors in analyzing the dentition for linear enamel hypoplasia.

CHAPTER 4: RESULTS

4.1 Sample Demographics

The study sample (n=47) across both the Early Intermediate Period and Middle Horizon was composed of 24 males, 15 females, and eight individuals whose sex could not be determined. The eight individuals of indeterminate sex included subadults as well as adults who could not be given a sex determination due to incompleteness. The age-at-death distribution was three subadults, 25 young adults, 14 middle adults, and five older adults. In comparison to the human skeletal worksheets in the Field Museum database (1986), only five of my estimations differed from the museum's. Individual 171096 was documented as an adult male while my observations recorded an older adult female. The worksheet from the museum only lists the individual as male due to 'robust cranium.' However, robustness may be evident in females of older age. In my observations, this individual was determined female despite robustness due to small mastoid processes and rounder orbits. For individuals 170834, 170982, 171004, and 171008, these individuals were listed as adult indeterminates due to incompleteness. My age estimations correlated with those documented, but my observations determined them all to be female with the available cranium. The Field Museum's worksheets also only list ages as adults or subadult. There is no distinction between young, middle, or older adult.

	Cahuachi	Cantayo	Huayrona	La Estaqueria	Majoro Chico	Ocongalla	Soisongo	Total
EIP & MH	18/47 (38%)	9/47 (19%)	2/47 (4%)	1/47 (2%)	8/47 (17%)	3/47 (6%)	6/47 (13%)	47/47 (100%)
Subadult	2	0	0	0	0	0	1	2
Young Adult F/PF	1	3	0	0	3	1	2	10

Young Adult M/PM	5	1	1	0	2	1	2	12
Young Adult IND.	3	0	0	0	0	0	0	3
Middle Adult F/PF	0	1	1	0	0	1	0	3
Middle Adult M/PM	3	3	0	1	2	0	1	10
Middle Adult IND.	0	0	0	0	1	0	0	1
Older Adult F/PF	2	0	0	0	0	0	0	2
Older Adult M/PM	1	1	0	0	0	0	0	2
Older Adult IND.	1	0	0	0	0	0	0	1

Table 3. Study Sample Distribution Between the Seven Sites by Sex and Age Estimation.

All 47 individuals from this sample were from one of seven sites excavated during Kroeber's Marshall Field Expeditions: Cahuachi (18), Cantayo (9), Huayrona (2), La Estaqueria (1), Majoro Chico (8), Ocongalla (3), and Soisongo (6). Regarding associated time periods, this sample was distributed from the Early Intermediate Period to the Middle Horizon. The Early Intermediate Period individuals were dated to either Early Nasca (19) or Late Nasca (10). 18 individuals were dated to the Middle Horizon.

4.2 Cranial Modification

Cranial Modification Presence/Absence During the Early Intermediate Period: Males vs. Females

83% (24/29) of individuals from the Early Intermediate Period exhibited signs of cranial modification. Eight of these were female (28%), 15 male (41%) and one was a subadult (3%). Comparisons of Early and Late Nasca were not statistically significant for cranial modification between sex (Chi square, p=.77).

Cranial Modification Presence/Absence During the Middle Horizon: Males vs. Females

Results						
	Cranial Def.	No Cranial Def.				*Row Totals*
Females	1 (3.33) [1.63]	4 (1.67) [3.27]				5
Males	7 (5.33) [0.52]	1 (2.67) [1.04]				8
Indeterminate	4 (3.33) [0.13]	1 (1.67) [0.27]				5
Column Totals	12	6				18 (Grand Total)

The chi-square statistic is 6.8625. The *p*-value is .032346. The result is significant at $p < .05$.

Figure 8. Chi Square comparing cranial modification between sex for the Middle Horizon.

For the Middle Horizon, 67% (12/18) of the individuals had cranial modification. Females represented 6% (1/18), males 39% (7/18), and subadult/indeterminate adult 22% (4/18). There was statistical significance between sex and cranial modification when looking at only the Middle Horizon individuals (Chi square, p= .03) (Figure 8).

Comparison of Cranial Modification Presence/Absence Between Both Time Periods

Results						
	EIP	MH				*Row Totals*
Female	8 (6.67) [0.27]	2 (3.33) [0.53]				10
Male	15 (14.00) [0.07]	6 (7.00) [0.14]				21
Indeterminate	1 (3.33) [1.63]	4 (1.67) [3.27]				5
Column Totals	24	12				36 (Grand Total)

The chi-square statistic is 5.9143. The *p*-value is .051967. The result is *not* significant at $p < .05$.

Figure 9. Chi square comparing Early Intermediate Period and Middle Horizon for cranial modification between sex.

When examining the Early Intermediate Period and Middle Horizon, there is an overall 77% (36/47) presence of cranial modification with the entire sample. However, when comparing the two, there is no significant difference between presence of absence of cranial modification from the Early Intermediate Period to the Middle Horizon. There was no statistical significance when comparing Early and Late Nasca to the Middle Horizon as well. In comparing cranial modification presence in sex between the two time periods, while not statistically significant, the p-value is approaching significance (p=.0519) (Figure 9)

4.3 Trophy Heads

Trophy Head Presence/Absence During the Early Intermediate Period: Males vs. Females

Between both sexes, trophy head presence was only in about 17% (5/29) of the EIP population. Females represented about 3% (1/29) of the trophy heads, while males represented 10% (3/29). In analyzing Early Nasca and Late Nasca, there was no statistical significance between the two sections of the Early Intermediate Period.

Trophy Head Presence/Absence During the Middle Horizon: Males vs. Females

Results						
	Trophy Head	Non Trophy Head				*Row Totals*
Male	1 (2.95) [1.29]	7 (5.05) [0.75]				8
Female	2 (2.21) [0.02]	4 (3.79) [0.01]				6
Indeterminate	4 (1.84) [2.53]	1 (3.16) [1.47]				5
Column Totals	7	12				19 (Grand Total)

The chi-square statistic is 6.0713. The *p*-value is .048043. The result is significant at $p < .05$.

Figure 10. Chi square comparing trophy head presence between sex for the Middle Horizon.

From the Middle Horizon population (n=18), 33% were trophy heads (6/18). Females represented 11% (2/18) while no males were modified as trophy heads. (the amount 1 is placed in the trophy head presence for male because Chi Square does not accept a 0, but there were 0). Trophy head presence/absence during the Middle Horizon between sex was found to be statistically significant (chi square, p= .04) (Figure 10).

Comparison of Trophy Head Presence/Absence Between Both Time Periods

Results						
	Trophy Head	Non Trophy Head				*Row Totals*
Male	3 (5.62) [1.22]	21 (18.38) [0.37]				24
Female	3 (3.51) [0.07]	12 (11.49) [0.02]				15
Indeterminate	5 (1.87) [5.22]	3 (6.13) [1.60]				8
Column Totals	11	36				47 (Grand Total)

The chi-square statistic is 8.5098. The *p*-value is .014194. The result is significant at $p < .05$.

Figure 11. Chi square test on sex and trophy head presence/absence between the Early Intermediate Period and Middle Horizon.

Overall, trophy head presence for the entire sample was 23% (11/47). When contrasting the Early Intermediate Period to the Middle Horizon, there is no statistical significance of trophy head presence or absence for any sex. Statistical analysis was performed comparing Early and Late Nasca to the Middle Horizon, neither of which were significant. When analyzing the entire sample population regardless of associated time period (n=47), statistical significance was found between sex (chi square, p=.014) (Figure 11).

4.4 Linear Enamel Hypoplasia

Presence/Absence of LEH During the Early Intermediate Period: Males vs. Females

Results						
	LEH Presence	LEH Absence				*Row Totals*
Early Nasca	17 (14.41) [0.46]	2 (4.59) [1.46]				19
Late Nasca	5 (7.59) [0.88]	5 (2.41) [2.77]				10
Column Totals	22	7				29 (Grand Total)

The chi-square statistic is 5.575. The *p*-value is .018218. The result is significant at $p < .05$.

Figure 12. Chi square comparing LEH of Early and Late Nasca periods of the Early Intermediate Period.

Results						
	LEH Presence	LEH Absence				*Row Totals*
Early Nasca	11 (8.47) [0.76]	1 (3.53) [1.81]				12
Late Nasca	1 (3.53) [1.81]	4 (1.47) [4.35]				5
Column Totals	12	5				17 (Grand Total)

The chi-square statistic is 8.7314. The *p*-value is .003128. The result is significant at $p < .05$.

Figure 13. Chi Square comparing LEH of Early and Late Nasca periods in Males.

Linear enamel hypoplasia was present in 76% (22/29) of the Early Intermediate Period sample. Females represented 28% (8/29) and males represented 41% (12/29) of the LEH presence. The Early versus Late Nasca sample was statistically significant for LEH presence/absence (chi square, p=.018) (Figure 12). This was with the overall sample, not distinguishing between male or female. However, there was statistical significance between Early Nasca and Late Nasca with males (chi square, p=.003) (Figure 13). This was not significant in females.

Presence/Absence of LEH During the Middle Horizon: Males vs. Females

The Middle Horizon sample had a 78% (14/18) presence of linear enamel hypoplasia. Females represented 33% (6/18) and males represented 28% (5/18) of the presence of LEH. Chi square test of independence resulted in a non-statistically significant result for males and females in the Middle Horizon.

Comparison of LEH Severity and Prevalence Between Both Time Periods

Results						
	LEH Presence	LEH Absence				*Row Totals*
EIP	22 (22.21) [0.00]	7 (6.79) [0.01]				29
MH	14 (13.79) [0.00]	4 (4.21) [0.01]				18
Column Totals	36	11				47 (Grand Total)

The chi-square statistic is 0.0227. The *p*-value is .880143. The result is *not* significant at $p < .05$.

Figure 14. Chi Square comparing LEH of entire sample (47) between Early Intermediate Period and Middle Horizon.

Both time periods resulted in a 77% (36/47) presence of linear enamel hypoplasia. The result for LEH presence for the entire population sample was not statistically significant (Figure 14). Comparisons of linear enamel hypoplasia presence/absence between the two time periods was not statistically significant as well. Comparisons of Early and Late Nasca to the Middle Horizon resulted in non-statistically significant results.

Linear Enamel Hypoplasia Severity with Cranial Modification

Results			
	LEH Presence	LEH Absence	***Marginal Row Totals***
Cranial Def.	25	11	36
No Cranial Def.	11	0	11
Marginal Column Totals	36	11	47 (Grand Total)

The Fisher exact test statistic value is 0.0457. The result is significant at $p < .05$.

Figure 15. Fisher exact test on LEH and cranial modification presence/absence.

For the entire population sample, correlation between LEH presence/absence and cranial modification was statistically significant (chi square, p=.045) (Figure 15). Lack of linear enamel hypoplasia was correlated with presence of cranial modification.

Linear Enamel Hypoplasia Presence/Absence With Trophy Heads

Correlation between linear enamel hypoplasia and trophy heads was not statistically significant.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Discussion

Cranial Modification

While the purpose of trophy heads is still debated, cranial modification was clearly used to demarcate groups and possibly promote cohesion within a society. Modified crania were not only aesthetic, but also conveyed important social information for the Andean region. Cranial modification has been interpreted as a marker of geographic origin, ethnic affiliation, kinship, sex, and social identity (Gomez-Mejia et al. 2021). However, caution is required with the use of concepts or variables that differ from sex or cranial modification because bioarchaeologists produce data on categories of identity, which are constructed from the modern mind, not necessarily culturally meaningful to ancient peoples as noted by Gomez-Mejia and colleagues (2021). In my study, 77% (36/47) of the overall sample displayed evidence of cranial modification. Pechenkina and Delgado (2006) examined social status of 64 individuals from the Villa El Salvador XII skeletal collection of the Lurín Valley of the central coast, dating to the Early Intermediate Period. They noted presence of cranial modification and also classified the type of modification per individual and found 62.3% of the skulls were mildly affected (Pechenkina & Delgado 2006). Gomez-Mejia et al. (2021) also investigated cranial modification presence on 159 Cerro Colorado individuals from the Paracas Cavernas period housed in the Museo Nacional de Antropologia, Arqueologia e Historia del Peru (MNAAHP). While this sample is from the Early Horizon, it is close to Nasca. Among the 159 individuals examined by Gomez-Mejia and colleagues (2021), 98.1% exhibited evidence of cranial modification. Kellner's (2002) study had pervasive evidence of cranial modification at 85% (n=117) in the entire collection, regardless of time period. Kellner (2002) documents the highest rates of unmodified individuals appear from the Middle to Late Nasca periods, while the most homogeneity of modification occurs during the Middle Horizon. All of these studies, including mine, compare well with one another as the majority of the sample population displays evidence of cranial modification.

As of 2021 when I conducted this study, extreme wear, fracturing, etc. was evident on the examined crania. Due to this fragmentation, differentiating between cranial modification type was challenging in this study. As will be discussed below, six of the trophy heads examined revealed evidence of typical Nasca cranial modification. This type of modification primarily comprised a flattened frontal bone and expansion of the parietals. Recent studies have revealed further differentiations between cranial modification type in the Andes (Andrushko 2021), but that was not performed for this current study due to sample conditions and available time and resources. For the non-trophy head crania that were identified as having cranial modification, frontal flattening and parietal expansion were evident. This suggests that this sample likely identified with the Nasca culture or participated in the Nasca cultural sphere. The individuals who presented this type of modification were most likely from the region and not foreigners. Further analysis should be conducted focusing solely on more in-depth identification of modification type as well as on the individuals who did not display CVM. Those results may reveal more information on the identities of this sample and identify Nasca locals versus foreigners.

This study focused more on the correlations of cranial modification and sex. Opposed to other studies (Blom 1999; Torres-Rouff 2002), this study did find a correlation between the cultural practice and sex estimates. Particularly when analyzing only the Middle Horizon, there was a statistical significance ($p=.03$) in comparing males to females. Males represented 39%

(7/18) of the sample while only one female and four indeterminate adults displayed cranial modification. This result may point to a societal focus on males in comparison to females. Alternatively, this could be skewed due to the indeterminate cases. Cranial modification was aligned with local identity and lack thereof could result in lack of local kin, lack of access to resources, etc. This would result in increased impacts of stress and disease. Cranial modification may be connected to status in society, which could be reflected by the fact that the only individuals without LEH had modified crania. Males, if perhaps associated with higher status, would have more opportunities and access to resources than females and vice versa. The osteological paradox is also to be considered when looking at these results. CVM is performed over the course of early childhood when the crania is malleable and able to be formed by outside forces. The lack of females with cranial modification may indicate an increase in female child/infant mortality. While females may have been given this local marker and may have begun the cranial modification process, if male infants were prioritized in care, female infants would be at higher risk for stress, disease, and earlier death.

Differences between the Early Intermediate Period to the Middle Horizon cranial modification approach significance (p=.0519). These results may indicate a decline in cranial modification during the Wari empire. Andrushko (2021) revealed that the Middle Horizon coincided with an influx of unmodified crania in the Cuzco region. However, other studies contradict this and show that cranial modification practices, while possibly changing, still occurred into the Wari empire in the Nasca region (Kellner 2002). For this study, these results may be due to small sample size and fragmentation which lead to the inability to identify the presence of CVM. A larger sample may clarify the extent of cranial modification in this region. Further analysis on the specific type of cranial modification present on individuals from the

Middle Horizon may reveal information on individuals aligning themselves with or against the Wari as hypothesized by Kellner (2002). Future studies would further inform on whether there was a decrease in this cultural practice once the Wari took over and on other fluctuations between the Early Intermediate Period and Middle Horizon.

Trophy Heads

In this study, 23% of the entire sample were trophy heads. The majority of trophy heads were of indeterminate sex, which included a subadult and adults. The issue of indeterminate sex is important because it may skew the data and interpretations. A sample of burials from Machu Picchu had originally been thought to mostly be female (Eaton 1916), but re-analysis showed there were actually more males. Native Andean males have been revealed to have less robust features and thus are often misidentified as females (Verano 2003). Females represented the second highest percentage of trophy heads, with males representing the least. When analyzing the sample of indeterminate trophy heads, they consisted of one older adult, three young adults, and one subadult. The majority of the trophy heads were those of young adults (64%, 7/11). Researchers, such as Uhle (1914), have claimed that the higher presence of younger adult male trophy heads is evidence for warfare trophies rather than religious or social power items since younger adults were the individuals inclined to fight in battle. However, in this sample, the majority of trophy heads were estimated to be female and at least one was a juvenile. This is similar to the analysis on trophy heads by Tello (1918), where he concluded that due to this inclusion of female and subadults, these were most likely not the heads taken of enemy warriors by the Nasca people (Tiesler & Lozada 2018). It is typically assumed that female and juvenile individuals would not be participating in battle. Extensive analysis on Nasca iconography displays images of warriors as being male. Nasca art strongly depicts imagery of violence and warfare. Males were often depicted as a chief, warrior, trophy head taker, coca chewer, farmer, fisherman, musician, and llama tender. On the other hand, females were often depicted performing duties such as leading llamas, carrying firewood, giving birth, or chewing coca. (Townsend 1985; Silverman 2019).

This correlation between sex and fighting can also be evidenced through skeletal trauma analysis. However, trauma analysis was not a focus in this current study. It is possible that if these trophy heads resulted from warfare and conflict, they may have been the victims of raids. If raiding did occur, it is difficult to determine if the perpetrators were Wari (during the Middle Horizon) or individuals from the local region during the EIP (Tung 2007). Knudson et al. (2009) utilized strontium, oxygen, and carbon isotope data from tooth enamel of Nasca trophy heads from Aja, Cahuachi, Cantayo, Majoro Chico and Paredones to find the origins of the heads. Their data suggest that the Nasca trophy heads they tested likely derived from the local Nasca population rather than obtained from enemy warriors through geographic expansion or warfare in other parts of the region (Knudson et al. 2009). Further analysis would need to be done on skeletal trauma and isotopic examination for this sample to examine this.

Characteristic of Nasca trophy heads were perforations distinctly in the center of the frontal bone (Tiesler & Lozada 2018). For this sample, all the perforations were located on the frontal bone, ranging from 9mm to 44mm above the nasion. This points to these trophy heads being distinctly Nasca. While being located in Ayacucho, Tung's (2012) study revealed that the Wari engaged in activities such as battles and raids and noted the production of heads from a range of demographic background including adults, subadults, males, and females. However, her study had considerably fewer females compared to males, whereas this sample contains more trophy heads identified as female rather than as male.

Along with the specificity of frontal perforation placement, the cranial modification characteristics of these heads can be used to identify significant markers of group identity. Williams et al. (2001) analyzed trophy heads including the 11 from this study's sample. However, while Williams et al. (2001) denoted that all the trophy heads depicted cranial modification, this study's analysis does not give the same result. Only 55% (6/11) of the trophy heads from this sample depicted unambiguous evidence of cranial modification. This may be due to the lapsed time between the two studies. Many of the crania were heavily fragmented as of 2021 which made it difficult to clearly identify evidence of cranial modification. Importantly, those who were able to be clearly identified with having cranial modification presented, like Williams et al. (2001) claimed, a distinctly Nasca pattern of cranial modification. This modification included flattening of the frontal bone and expansion, or widening, of the parietal bones. This would then suggest that these individuals shared the identity associated with this style of cranial modification and were less likely to be fighting amongst one another. Although interethnic violence, while it is not identified in this particular study, cannot be discounted as a possibility.

Lastly, based on the range in age and sex of trophy heads, it is possible they were collected for varying reasons, not simply one. Some of these individuals may have been collected as warfare trophies while others, such as the subadult and females, were collected for other reasons. Differentiating between time period did not present any statistical significance in changes of the presence of trophy heads. With the proposed increased violence and warfare associated with the rise of the Wari Empire, one would assume an increase in trophy heads if they were collected solely in warfare. However, there was no significant difference in trophy head presence between the Early Intermediate Period and Middle Horizon. When analyzing the time periods separately, there was statistical significance (p=.04) in trophy head presence during the Middle Horizon. Out of the six trophy heads dated to the Middle Horizon, the majority are indeterminate adults and one juvenile. The remaining two are female. This may indicate more of a ritualistic or social purpose to trophy head making as there were no identified males. However, as mentioned previously, Andean males are known to have more gracile features and often misidentified as females, so the presence of male trophy heads cannot be ruled out entirely (Verano 2003). Further investigation into examining the sex of these trophy heads will aid in this distinction. A lack of young adult male presence in trophy heads may indicate a decrease in violence/warfare after Wari imperial takeover. Wari imperialism may have stabilized the region. However, as discussed previously, females and juveniles may have been victims of raiding and other violence. As there is no clear answer as to the overall purpose of trophy head collecting, this study cannot conclude one over the other.

Linear Enamel Hypoplasia

The overall sample showed a 77% (36/47) presence of linear enamel hypoplasia during the Early Intermediate Period and the Middle Horizon. In looking at the stages of the Early Intermediate Period, there was statistical significance (p=.018) between Early Nasca and Late Nasca. According to the sample, there was a decrease in the amount of linear enamel hypoplasia presence from Early to Late Nasca. 17 individuals from Early Nasca showed evidence of LEH, while there was only five in Late Nasca. Perhaps higher presence of linear enamel hypoplasia in the Early Nasca stage indicates higher experienced stress for both sexes. This would then lead to the assumption of lower experienced stress during the Late Nasca stage. However, from Early Nasca, 92% (11/12) of the males, 100% (5/5) of the females and 50% (1/2) of the indeterminates displayed evidence of linear enamel hypoplasia. For the Late Nasca, LEH was present in 20%

(1/5) of the males, 75% (3/4) of the females and 100% (1/1) of the indeterminates. The results presented here are highly dependent upon this small sample size. Nonetheless when analyzing these results overall, there is a decline in linear enamel hypoplasia into Late Nasca.

In analyzing LEH presence between Early and Late Nasca for each sex, LEH presence was significant in males in Early Nasca, but not in females. This may suggest that young males were more likely to be impacted by stress than females, thus developing the hypoplasia. On the contrary, this may suggest females had a higher mortality rate during Early Nasca and males had higher survivability. This would result in females dying before LEH could form and thus provide the results that females had less LEH rates than males. However, in Late Nasca, per the female group size, there was a higher amount of LEH presence than in the male group. Perhaps in the upheaval occurring at this time, higher priority was placed upon males. Care and access to resources may have been allocated more to male children, causing females to be more heavily impacted despite both sexes experiencing the same stress.

Once again, the osteological paradox becomes important in discussing these results. In Early Nasca, females were more likely to demonstrate linear enamel hypoplasia, although by a narrow margin. This may be due to sample size or possibly mortality. If higher priority, such as social prestige, was placed upon males at this time, females may have had a higher mortality rate and died before LEH could form on the dentition. However, the data collected in this study contradicts this since females had higher amounts of LEH. Higher resilience may have been experienced by female children and males had higher mortality rates.

In Late Nasca, there are similar issues concerning the osteological paradox. With such a small sample size, this study is unable to determine the full extent of linear enamel hypoplasia. Females had higher rates of LEH, which may mean they were more heavily impacted by stress;

or perhaps males were more heavily impacted and died before LEH could form. This would mean females were more resilient at this time. However, if the opposite is true with females having higher mortality and dying before LEH could form, then perhaps males were more resilient. The individuals who present linear enamel hypoplasia would then be the individuals resilient to disease and stress and lived long enough for the dental lesions to form.

Based on the available sample data, this study would indicate in the Late Nasca that there was an overall decline in linear enamel hypoplasia, but females still retained a higher presence of LEH. A larger sample would be needed to further study for these comparisons. Kellner (2002) found that the lowest rates of enamel hypoplasia occurred during Early Nasca in the Nasca region. According to Kellner's (2002) data, Late Nasca was predicted to have the worst health. However, her results show a mixture of high and low rates, with enamel hypoplasia being relatively low during this period. Kellner (2002) predicts that this may be due to changes in disease transmission due to stress of larger population size. Again, the osteological paradox is an important factor to take into account as the low rate of enamel hypoplasia may be a result of higher mortality rates before the dentition could be affected.

During the Early Intermediate Period and Middle Horizon, there were evident fluctuations in the presence of linear enamel hypoplasia. During Early Nasca, 89% (17/19) of the sample had evidence of LEH. Moving into Late Nasca, there was a decrease to only 50% of the individuals having LEH. Rates of linear enamel hypoplasia rose back up to 78% (14/18) in the Middle Horizon. Kellner (2002) supported the hypothesis that the Middle Horizon had extremely unhealthful conditions. Many stress indicators were at their highest or most severe during this time period in the Nasca region. Kellner (2002) notes that the Middle Horizon sample displayed the highest rates of enamel hypoplasia than the other time periods (Figure B10). She hypothesizes that this is due to exposure to infectious disease and possible decline in quality of diet due to living in larger populations. While, for my study, the Middle Horizon did not have the highest rates of LEH, the rates did rise once again from Late Nasca into the Middle Horizon. Throughout all three periods, females continued to average the highest rates of linear enamel hypoplasia. While these rates are highly dependent upon the small sample size, it does provide insight into what may have been occurring from the Early Intermediate Period to the Middle Horizon. Rates seemingly dropped from Early to Late Nasca for males and females, though more significantly for males. Perhaps the entire population, regardless of sex, was not greatly affected by stress at this time.

However, as research has shown, in the Transitional period into Late Nasca, there was much upheaval and violence occurring (Kellner 2002). Violence and warfare, while males tended to be the warriors, was experienced by both sexes. When thinking about the osteological paradox, the evident decline in LEH presence may have been due to higher mortality and less resilience to stress at this time. This conclusion compares well with Kellner's (2002) hypothesis that the Late Nasca period was a time of considerable interpersonal conflict. The rise of the Wari empire in the Middle Horizon stabilized the region in some ways, though health status was still seemingly poor. All the females and 71% of males from this time period had evidence of LEH. This result may be due to the stability caused by the expansion of the Wari empire, causing early mortality to decline. People were not dying early in life and thus were able to live long enough for linear enamel hypoplasia to form on the dentition. This would lead to the resulting higher percentages of LEH for the Middle Horizon individuals found in this study.

When comparing the occurrence of LEH and in trophy heads and those individuals with cranial modification, statistical significance was found between LEH presence and cranial modification. While LEH was present in some individuals who had cranial modification, there was greater statistical significance in that every individual who did not have any evidence of cranial modification had linear enamel hypoplasia. However, in analyzing the associated age groups to the individuals with no cranial modification, only one individual was a subadult. The rest were young, middle, or older adult. At those ages, if cranial modification were to take place, there would already be evidence of such.

The correlation of unmodified crania and LEH may be due to a lack of special status in society with the Nasca culture. Velasco (2018) notes that feelings of shared identity that foster group solidarity can also mobilize ideologies of essential difference. Perhaps lack of cranial modification and this connection to the Nasca identity resulted in less group solidarity and therefore, lower resilience to stress and disease. This lack of a visible marker of identity with others within the culture may have resulted in less access to resources and aid from the group. Overall, it makes sense that those with CVM would be those of higher status, who had more access to resources and support, than those who did not have cranial modification. The majority of these individuals with unmodified crania were female (5/11) and from the Middle Horizon (6/11). With the majority of these individuals being from the Middle Horizon, this may show a change or shift in cranial modification practices after the Wari Empire took power. Kellner's (2002) results from the Nasca region showed a rise in the annular form of cranial modification during the Middle Horizon, potentially pointing to individuals aligning themselves with Wari. Kellner's data supported the hypothesis that there was a homogeneity occurring in cranial modification during this time. Perhaps the results of my present study are more skewed due to sample size and fragmentation, which could have inhibited the identification of cranial modification. Further focus on cranial modification specifically in this sample or with a large sample size from this region may produce further information on the effects of Wari expansion and cranial modification practices and its relation to stress experienced by the population.

Also, while not a topic of this study, trauma was evident on some of the remains. Trauma is evident on #170469, a middle adult male who was dated to the Middle Horizon. This individual has a healed depression on the left frontal and temporal bones. Trauma was also noted on #170224, a Middle Horizon indeterminate young adult. This individual was a trophy head with a healed depression on the posterior crania on the superior lambda (Williams et al. 2001). The individuals who clearly displayed healed trauma, while a considerably small sample, were both from the Middle Horizon. While identifying trauma was not the focus of this study, it is important to note. An increase in trauma during the stages of the Early Intermediate Period or in the Middle Horizon may be indicative of increased violence in the region which could coincide with the rise of the Wari empire. Kellner (2002) discussed post cranial and cranial trauma for her Nasca sample. That study revealed high rates of post-cranial and cranial trauma in Early Nasca which is hypothesized to be from interpersonal conflict. Late Nasca displays the second highest rates of cranial trauma which supports that this period was also a time of considerable interpersonal conflict. In the Middle Horizon, cranial trauma rates are low with rib fractures being common. Kellner (2002) notes that while female cranial trauma rates decline, male rates rise to their highest. Kellner (2002) posits that if the Chakipampa individuals were allied with the Wari or Wari themselves, they may have been targeted by the local Loro males. Future studies on trauma specifically with this sample would aid in understanding of differentiations between violence and stress between the Early Intermediate Period and Middle Horizon for the Nasca people.

5.2 Conclusions

Amongst the research on Nasca skeletal remains and linear enamel hypoplasia in the Andes, this is the first study to focus specifically on Nasca and LEH together in an analysis comparing the Early Intermediate Period to the Middle Horizon. These data were used to test the hypothesis of LEH prevalence and evident disparities between Nasca males and females and in relation to health status, cranial modification, and trophy heads, which I compare with studies by various other researchers working in Nasca and other regions of the Andes (see Blom 1999; Andrushko 2021; Torres-Rouff 2002; Kellner 2002; Uhle 1914; Tello 1918; Tiesler & Lozada 2018; Townsend 1985; Silverman 2019; Tung 2007). In this sample, enamel defects were prevalent in Nasca throughout the Early Intermediate Period and Middle Horizon. During the Early Intermediate Period, Early Nasca had significant rates of LEH. In comparing sex at this time, LEH was significant only in males. The Middle Horizon revealed males had higher rates of cranial modification as well. In the Middle Horizon, there was significance of indeterminate trophy heads, however as discussed, Andean males have been known to be more gracile. Further investigation into distinguishing the sex of these adult indeterminates may provide more information on trophy heads at this time. For the overall sample, regardless of time period, all individuals with no cranial modification displayed evidence of linear enamel hypoplasia. LEH prevalence between Early and Late Nasca and the Middle Horizon did differ, though were not statistically significant. The rates fluctuated throughout time with a decrease in Late Nasca and subsequent increase in the Middle Horizon. However, as discussed, these results may be influenced by the osteological paradox. Lack of linear enamel hypoplasia might not be evidence of less experienced stress, but of higher experienced stress and mortality, therefore individuals were dying before LEH could form on the dentition. These fluctuations in linear enamel hypoplasia, cranial modification, and trophy head rates coincide with fluctuating environmental and socio-political conditions that were occurring between the Early Intermediate Period and Middle Horizon in Nasca, Peru.

The results of the analysis of 47 Nasca individuals from the Kroeber collection from the Field Museum in Chicago, Illinois show an interesting health decline from the EIP to the Middle Horizon. Due to fluctuating environmental and political conditions in the region, the Early Intermediate Period saw a decrease in linear enamel hypoplasia from Early to Late Nasca and a subsequent rise in the Middle Horizon. This could be hypothesized as a decrease in experienced stress during the Early Intermediate Period and increased stress during the Middle Horizon following Wari imperialism. However, lack of linear enamel hypoplasia may be a result of higher mortality rates in Late Nasca according to the osteological paradox. While not statistically significant, females tended to show more presence of LEH than males. This may be due to male mortality being higher or females experiencing more impact of stress than their male counterparts.

Cranial modification in this study was of significance as well. Individuals who did not portray evidence of cranial modification all had signs of LEH as opposed to those who did have cranial modifications. This likely suggests that some individuals held special status which helped them thrive. Overall, evident in the transitions occurring during the Early Intermediate Period and Middle Horizon, LEH rates increase in Early Nasca, fall in Late Nasca, and rise once again in the Middle Horizon. Similarly, Kellner (2002) documents a decrease in hypoplasia rates in Late Nasca and an increase in the Middle Horizon as seen in Figure B10.

The Middle Horizon showed interesting results in that cranial modification at this time was higher in males than females given the present sex estimations. As discussed above, further sex determination on the adult indeterminates may provide different results. This may indicate a change in the practice of cranial modification after the Wari empire took power as proposed by Kellner (2002). Middle Horizon trophy heads showed a decline in males and females. However, the rates were higher in indeterminates who included a mixture of subadult and adults of indeterminate sex. This result and others were highly impacted by limited sample size in this study.

Further research with a greater sample size on this population, if possible, could aid in supplementing the results of this study. More specialized examination on individuals labeled indeterminate may provide further information into sex differences at this time in regard to linear enamel hypoplasia, cranial modification, and trophy heads. While noted in materials and methods, this study did not fully measure the extent of LEH on individuals from this sample. A future study on how many lines of LEH were present on individuals may also provide valuable information on those who experienced continuous stress and survived. Future analysis using strontium isotope data or other chemical analysis may aid in revealing the migration pattern for trophy heads and those with or without cranial modification. This data can be used to identify the movement and migration of these individuals and whether they were from Nasca. Those results have the potential to reveal essential information regarding the purpose of the trophy heads in this sample. Also, further investigation on individuals without cranial deformation may aid in revealing information as to their homeplace and further explain the impact of identity on experienced stress and LEH.

This study compared well with other studies, such as Kellner (2002), with similar fluctuations in enamel hypoplasia between time periods, though the effect of small sample size of this collection may have had an impact on the estimation of health in the Nasca population.

This research highlights the need for future research into this region and specifically between the Early Intermediate Period and Middle Horizon. This was a time of constant change and the rise of an empire. This and further research would help in analyzing the issues of relationship between resources, stress, and development of social complexity. While still developing new methods, skeletal and linear enamel hypoplasia analysis can provide fundamental knowledge important to anthropology and archaeology. These analyses can aid in the understanding of the strategies employed by ancient populations to deal with changing political conditions as well as the effects of stress and disease due to these conditions.

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APPENDIX A: TABLES

Table A 1. Category, Sex, Age, Number of Afflicted Dentition, Average LEH per individual, and Mode of LEH per individual from this study.

Catalog #	Sex	Age	# Of Teeth Afflicted	Average LEH	LEH Mode
171041	FEMALE	YA	2	1	1
171096	FEMALE	OA	9	1.4444	1
170493	FEMALE	YA	8	1	1
171136	FEMALE	YA	6	1	1
170484	FEMALE	YA	1	1	3
171098	IND.	YA	10	1.6	2
170832	IND.	SA	4	2	2
171185	IND.	OA	1	1	1
171023	MALE	MA	1	1	1
170222	MALE	YA	4	1	1
170843	MALE	YA	2	1	1
170521	FEMALE	YA	4	1.5	
170579	FEMALE	MA	5	1	1
170656	FEMALE	YA	0	0	0
170797	FEMALE	YA	6	1.8333	2
170834	FEMALE	YA	6	1.3333	1
171163	FEMALE	OA	1	2	2
170781	FEMALE	MA	4	1.5	
170982	FEMALE	MA	5	1	1
171004	FEMALE	YA	22	1.7272	2
171008	FEMALE	YA	3	1	1
171100	IND.	SA	0	0	0
171099	IND.	YA	5	1.6	1
170224	IND.	YA	1	1	1
170225	IND.	SA	0	0	0
170486	ind.	MA	0	0	0
171013	MALE	MA	0	0	0
170499	MALE	YA	5	2	2
170469	MALE	MA	6	1.1667	1
170123	MALE	YA	0	0	0
170871	MALE	MA	1	1	1
171025	MALE	OA	4	1	1
170220	MALE	MA	2	1	1
170221	MALE	MA	4	1	1
171307	MALE	MA	3	1	1
171240	MALE	YA	9	1.4444	1
171259	MALE	YA	6	1.1667	1

171260	MALE	YA	9	1.3333	1
171263	MALE	YA	8	1.75	2
170820	MALE	YA	5	1	1
171346	MALE	OA	0	0	0
170422	MALE	YA	0	0	0
170489	MALE	YA	0	0	0
170810	MALE	MA	0	0	0
170950	MALE	YA	0	0	0
170979	MALE	MA	1	1	1
170463	MALE	MA	4	1.5	1

Table A 2. LEH Presence/Absence, Cranial Modification Presence/Absence, and Trophy Heads by Age Group for Both Time Periods.

	Overall	**LEH Presence**	**LEH Absence**	**Cranial Mod. Presence**	**Cranial Mod. Absence**	**Trophy Head**	**Non-Trophy Head**
Age							
Subadult	3/47 (6%)	1	2	2	1	1	2
Young Adult	25/47 (53%)	20	5	18	7	7	18
Middle Adult	14/47 (30%)	11	3	13	1	1	13
Older Adult	5/47(11%)	4	1	3	2	2	3

Table A 3. LEH Presence/Absence, Cranial Modification Presence/Absence, and Trophy Heads by Age Group and Sex for the Early Intermediate Period.

	LEH Presence	**LEH Absence**	**Cranial Mod. Presence**	**Cranial Mod. Absence**	**Trophy Head**	**Non-Trophy Head**
EIP	**22/29 (76%)**	**7/29 (24%)**	**24/29 (83%)**	**5/29 (17%)**	**5/29 (17%)**	**24/29 (83%)**
Subadult	1	1	1	1	0	2
Young Adult F/PF	5	1	5	1	1	5
Young Adult M/PM	8	3	9	2	2	9

Young Adult IND.	0	0	0	0	0	0
Middle Adult F/PF	2	0	2	0	0	2
Middle Adult M/PM	4	1	5	0	1	4
Middle Adult IND.	0	0	0	0	0	0
Older Adult F/PF	1	0	1	0	0	1
Older Adult M/PM	0	1	1	0	0	1
Older Adult IND.	1	0	0	1	1	0

Table A 4. LEH Presence/Absence, Cranial Modification Presence/Absence, and Trophy Heads by Age Group and Sex for the Middle Horizon.

	LEH Presence	**LEH Absence**	**Cranial Mod. Presence**	**Cranial Mod. Absence**	**Trophy Head**	**Non-Trophy Head**
MH	**14/18 (78%)**	**4/18 (22%)**	**12/18 (67%)**	**6/18 (33%)**	**6/18 (33%)**	**12/18 (67%)**
Subadult	0	1	1	0	1	0
Young Adult F/PF	4	0	0	3	1	3
Young Adult M/PM	0	1	2	0	0	1
Young Adult IND.	3	0	2	1	3	0
Middle Adult F/PF	1	0	1	0	0	1

Middle Adult M/PM	4	1	4	1	0	5
Middle Adult IND.	0	1	1	0	0	1
Older Adult F/PF	1	0	0	1	1	0
Older Adult M/PM	1	0	1	0	0	1
Older Adult IND.	0	0	0	0	0	0

Table A 5. LEH Presence/Absence, Cranial Modification Presence/Absence, and Trophy Heads by Age Group for Males for Entire Sample.

	LEH Presence	**LEH Absence**	**Cranial Mod. Presence**	**Cranial Mod. Absence**	**Trophy Head**	**Non-Trophy Head**
Male 24/47 (51%)	**17/24 (71%)**	**7/24 (29%)**	**21/24 (87%)**	**3/24 (13%)**	**3/24 (13%)**	**21/24 (87%)**
Subadult	0	0	0	0	0	0
Young Adult	8	4	10	2	2	10
Middle Adult	8	2	9	1	1	9
Older Adult	1	1	2	0	0	2

Table A 6. LEH Presence/Absence, Cranial Modification Presence/Absence, and Trophy Heads by Age Group for Females for Entire Sample.

	LEH Presence	**LEH Absence**	**Cranial Mod. Presence**	**Cranial Mod. Absence**	**Trophy Head**	**Non-Trophy Head**
Female 15/47 (32%)	**14/15 (93%)**	**1/15 (7%)**	**10/15 (67%)**	**5/15 (33%)**	**3/15 (20%)**	**12/15 (80%)**
Subadult	0	0	0	0	0	0
Young Adult	9	1	6	4	2	8

Middle Adult	3	0	3	0	0	3
Older Adult	2	0	1	1	1	1

Table A 7. LEH Presence/Absence, Cranial Modification Presence/Absence, and Trophy Heads by Age Group for Indeterminates for Entire Sample.

	LEH Presence	**LEH Absence**	**Cranial Mod. Presence**	**Cranial Mod. Absence**	**Trophy Head**	**Non-Trophy Head**
Indeterminate 8/47 (17%)	**5/8 (63%)**	**3/8 (37%)**	**5/8 (63%)**	**3/8 (37%)**	**5/8 (63%)**	**3/8 (37%)**
Subadult	1	2	2	1	1	2
Young Adult	3	0	2	1	3	1
Middle Adult	0	1	1	0	0	1
Older Adult	1	0	0	1	1	0

Table A 8. Number of Observed Lines of LEH Per Tooth Per Individual on the Maxillary Teeth (1-16). Teeth are numbered using the Universal Numbering System.

Cat. #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
171041	X	X	X	X	X	0	0	X	X	X	0	X	X	X	X	X
171096	1	1	1	1	2	3	X	X	X	X	2	1	1	X	X	X
170493	0	0	0	0	1	1	X	1	1	0	X	0	X	0	X	0
171136	X	0	0	X	1	X	X	X	X	X	X	X	0	X	X	X
170484	X	X	X	0	X	X	X	X	X	X	0	X	X	X	X	X
171098	X	2	2	X	X	X	X	X	X	X	X	1	0	2	2	1
170832	X	2	0	X	0	0	X	X	0	0	0	0	0	0	2	X
171185	X	0	0	0	0	0	X	X	X	X	X	0	0	0	1	X
171023	X	X	X	X	X	X	X	0	0	X	0	X	0	1	0	0

170222	X	X	X	1	1	X	X	X	X	X	X	1	0	0	X	0
170843	X	0	0	X	X	X	X	X	X	X	X	X	X	0	X	0
170521	X	X	X	0	1	X	X	X	X	X	X	X	X	1	X	X
170579	X	X	X	1	1	1	X	X	X	X	X	0	X	X	X	X
170656	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170797	X	X	X	X	X	2	X	2	2	X	1	X	X	0	X	X
170834	X	0	0	0	0	0	0	X	X	X	X	0	X	0	0	X
171163	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X
170781	X	0	0	1	1	2	X	0	X	X	2	X	X	X	X	X
170982	X	X	0	0	1	0	X	X	X	X	0	1	0	0	0	0
171004	X	X	X	1	1	2	2	2	2	2	2	1	1	X	0	X
171008	0	X	X	0	0	X	X	X	X	X	X	0	X	1	0	X
171100	X	X	X	0	0	0	0	0	0	0	X	X	0	X	X	X
171099	1	1	0	0	0	X	X	X	3	X	X	X	X	1	X	X
170224	X	0	1	X	X	X	X	X	X	X	X	X	X	X	0	X
170225	X	X	X	X	X	X	X	X	X	0	X	X	X	X	X	X
170486	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
171013	X	X	X	0	X	X	X	X	X	X	X	X	0	X	X	X
170499	0	0	0	0	0	0	0	0	X	X	X	2	2	2	X	2
170469	X	X	1	X	X	X	X	X	X	X	0	1	1	1	1	X
170123	X	0	0	X	X	0	X	X	X	X	X	X	X	X	X	X
170871	X	0	0	0	0	X	X	X	X	X	X	0	X	X	0	1
171025	X	X	X	X	X	X	X	X	X	X	X	0	X	0	X	X

170220	X	0	0	X	0	X	X	X	X	X	X	X	X	X	1	X
170221	X	1	1	1	X	X	X	X	X	X	X	X	X	X	1	X
171307	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X
171240	0	0	0	0	1	2	X	X	X	0	2	0	0	0	0	0
171259	X	2	X	1	X	1	X	X	X	X	X	X	X	1	1	X
171260	0	2	1	X	X	2	X	X	X	0	1	X	X	1	1	1
171263	X	0	1	X	X	X	X	X	X	X	X	X	X	0	X	X
170820	0	X	1	0	0	0	X	X	X	X	0	0	X	0	0	0
171346	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170422	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170489	X	X	0	X	X	X	X	X	X	X	X	X	X	0	0	0
170810	X	X	0	0	0	X	X	X	X	X	0	X	0	0	X	X
170950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170979	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X
170463	X	X	0	0	0	1	0	3	X	X	X	0	0	X	X	0

Table A 9. Number of Observed Lines of LEH Per Tooth Per Individual on the Mandibular Teeth (17-32). Teeth are numbered using the Universal Numbering System.

Cat. #	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
171041	X	X	X	0	0	0	0	X	0	0	0	1	1	X	X	X
171096	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170493	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
171136	0	X	X	1	1	0	0	1	1	X	X	0	1	X	X	X

170484	X	X	X	X	0	3	X	X	X	X	X	0	X	X	X	X
171098	X	X	X	X	X	X	X	X	X	X	X	X	2	2	1	1
170832	X	0	X	0	0	2	0	0	0	0	2	0	0	0	0	0
171185	X	X	0	X	0	X	X	X	X	X	0	0	0	0	0	X
171023	X	X	X	X	0	0	X	X	X	0	0	0	0	0	0	0
170222	X	X	X	0	0	X	X	X	X	X	X	1	0	0	X	X
170843	0	0	0	0	0	X	X	X	X	X	X	1	1	0	0	0
170521	X	2	0	X	X	0	X	X	X	X	X	X	X	0	2	X
170579	X	0	X	X	0	1	X	X	X	X	0	0	X	1	0	X
170656	X	0	0	0	X	X	X	X	X	0	X	X	0	X	X	X
170797	X	X	X	X	0	2	X	X	X	X	2	X	X	X	X	X
170834	0	0	1	1	1	3	X	X	X	X	X	0	1	1	0	0
171163	X	X	X	X	X	X	X	X	X	X	X	0	X	X	X	X
170781	0	X	0	0	X	X	X	X	X	X	X	0	0	0	X	0
170982	X	0	0	0	1	X	0	X	X	X	X	1	1	X	0	0
171004	0	0	1	2	2	2	2	2	2	2	2	2	2	1	0	0
171008	X	1	0	0	0	0	0	0	X	X	0	0	0	1	X	X
171100	X	X	X	0	0	X	X	X	0	X	X	0	0	X	X	X
171099	0	0	0	0	X	2	0	0	0	0	X	0	1	X	X	X
170224	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170486	X	X	X	X	0	X	X	X	X	X	X	X	X	X	X	X
171013	X	X	X	X	X	0	X	X	X	X	X	X	X	X	X	X

170499	X	X	2	X	X	X	X	X	X	X	X	X	X	X	X	X
170469	X	X	0	2	X	X	X	X	X	X	X	X	X	X	X	X
170123	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170871	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
171025	X	X	0	X	X	X	X	X	X	X	X	X	1	1	1	1
170220	X	X	X	X	0	X	X	X	X	X	X	X	X	0	1	X
170221	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
171307	X	X	X	X	X	0	1	X	X	X	1	X	X	X	X	X
171240	X	X	0	1	1	1	X	0	0	X	1	3	X	X	1	X
171259	1	X	X	X	0	X	X	X	X	X	X	X	X	X	X	X
171260	X	X	X	X	X	X	0	2	1	X	X	X	X	X	X	X
171263	0	X	0	X	2	0	0	X	0	2	3	2	2	1	1	X
170820	0	X	X	1	1	0	0	X	0	0	0	1	1	X	X	X
171346	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170422	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170489	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170810	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170950	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170979	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
170463	X	0	0	0	0	1	0	0	X	0	1	X	0	0	0	X

APPENDIX B: FIGURES

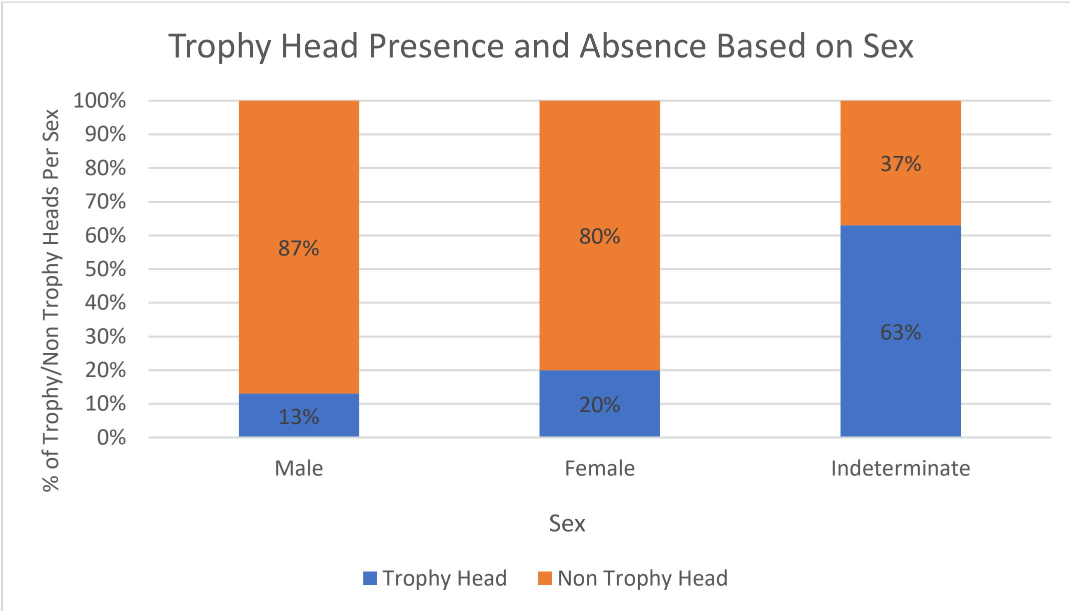

Figure B 1. Distribution of Trophy Head Presence/Absence by Sex for Entire Sample.

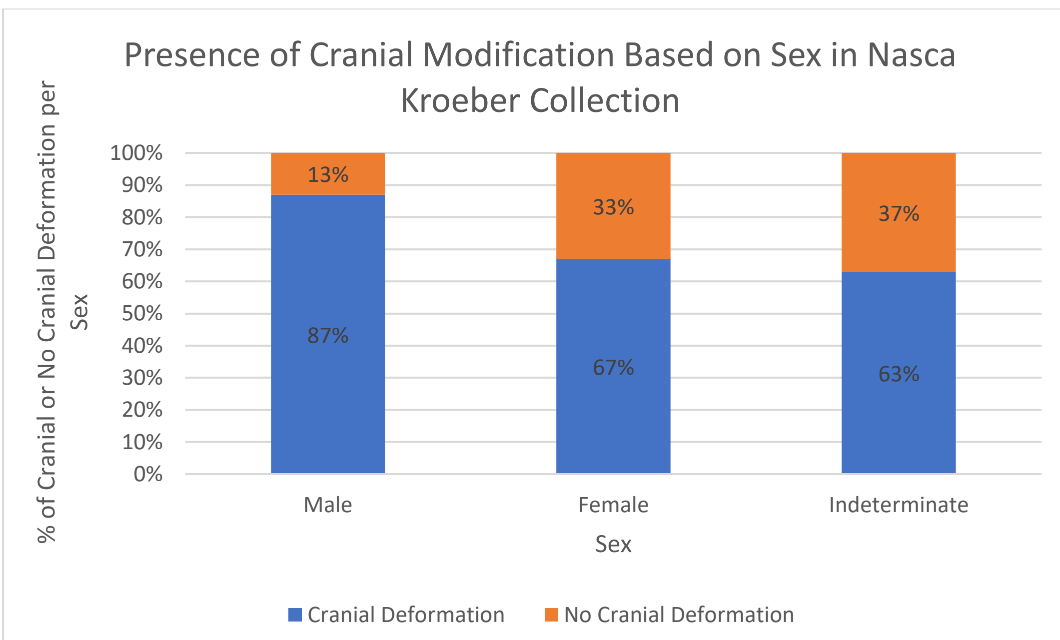

Figure B 2. Distribution of Cranial Modification Presence/Absence by Sex for Entire Sample.

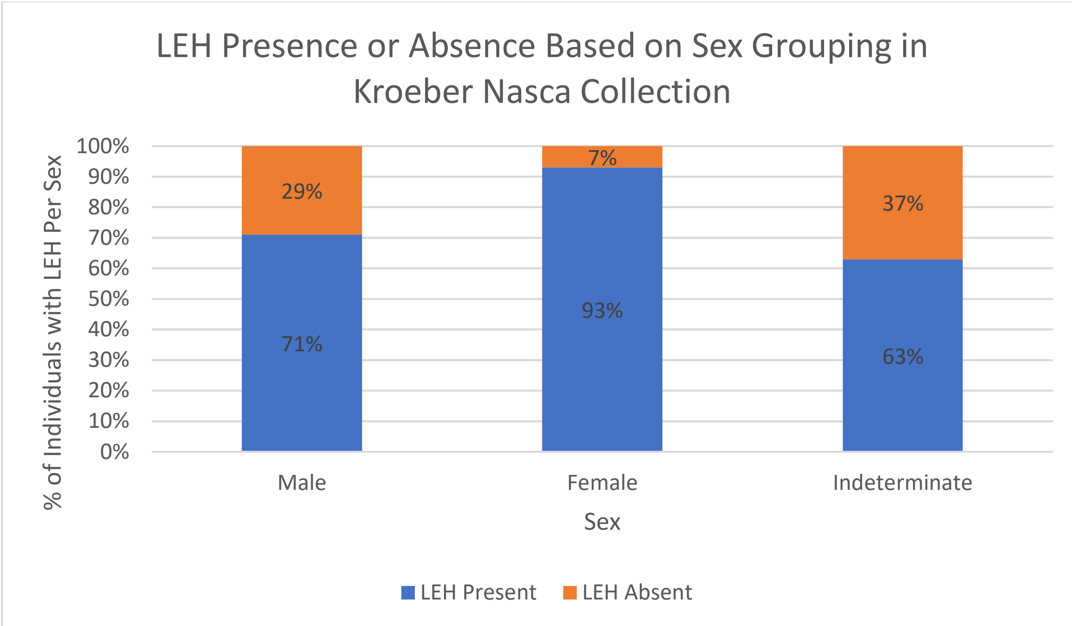

Figure B 3. Distribution of LEH Presence/Absence by Sex for Entire Sample.

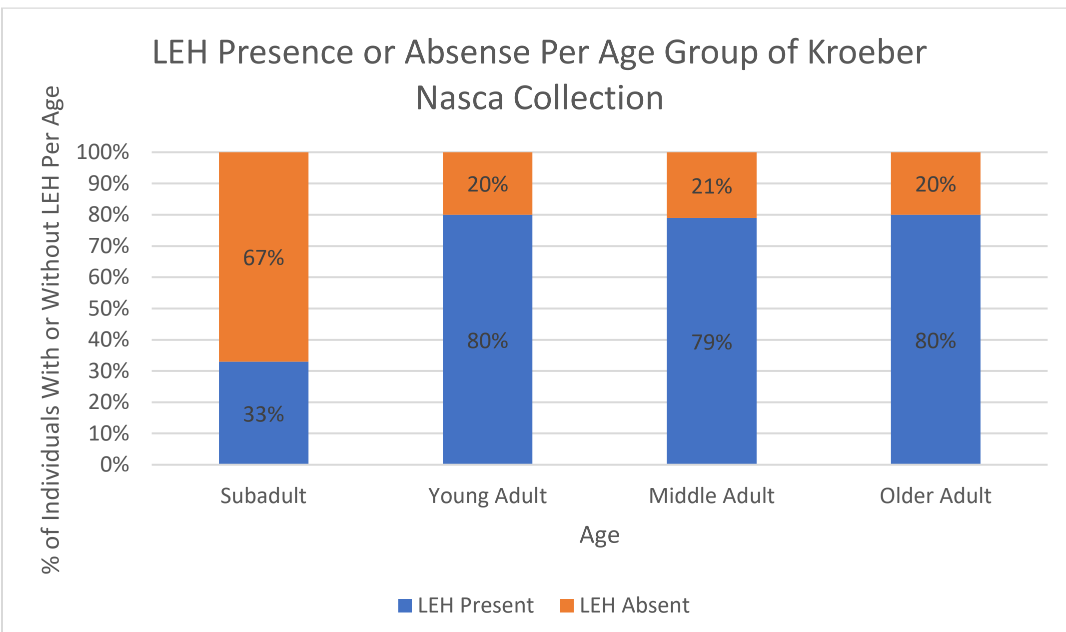

Figure B 4. Distribution of LEH Presence/Absence by Age Group for Entire Sample.

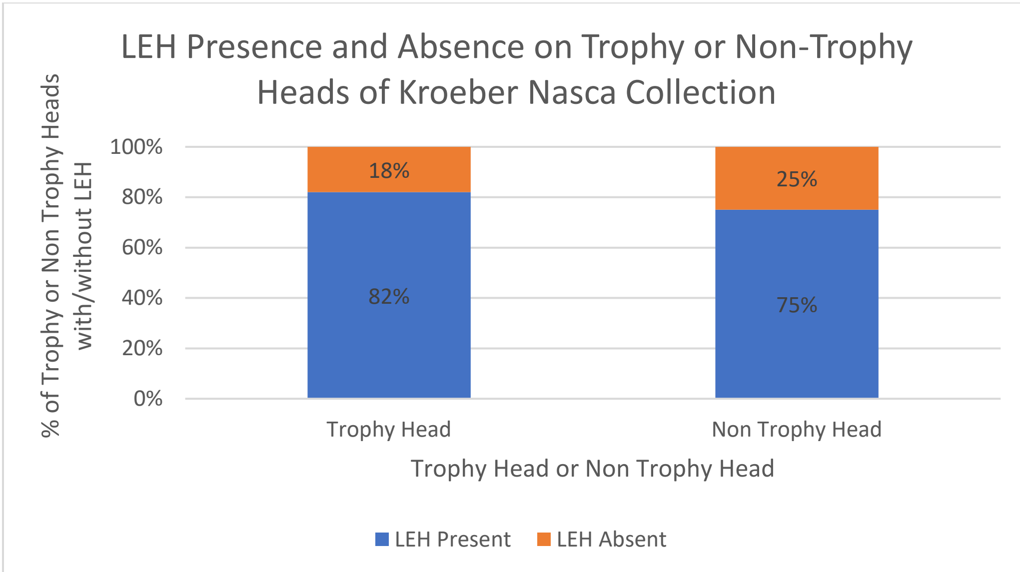

Figure B 5. Distribution of LEH Presence/Absence on Trophy and non-Trophy heads for Entire Sample.

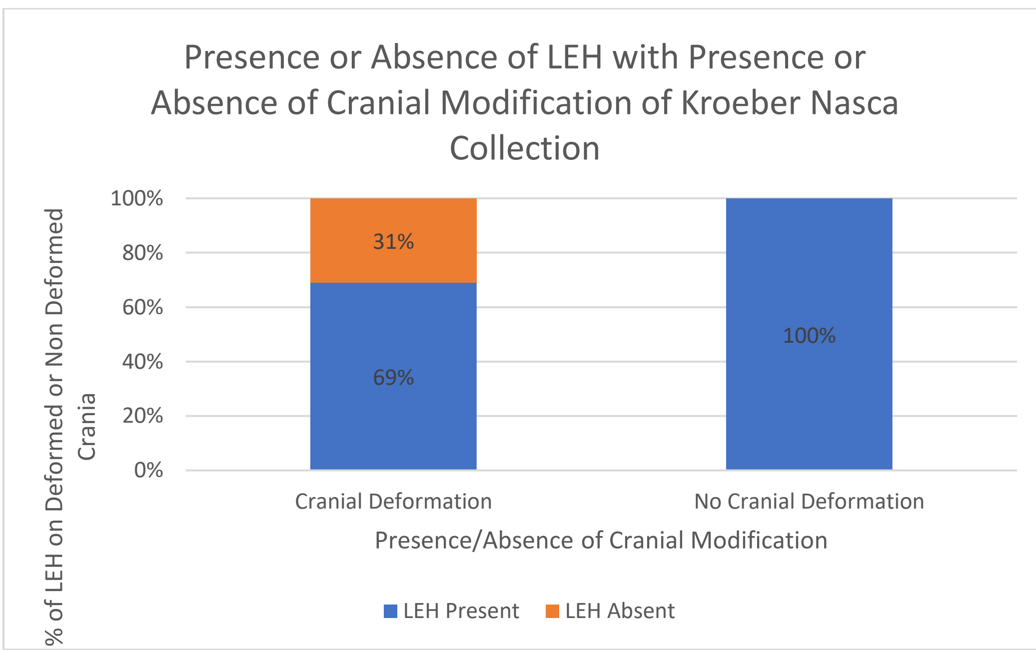

Figure B 6. Distribution of LEH Presence/Absence on Cranial Modification Presence/Absence for Entire Sample.

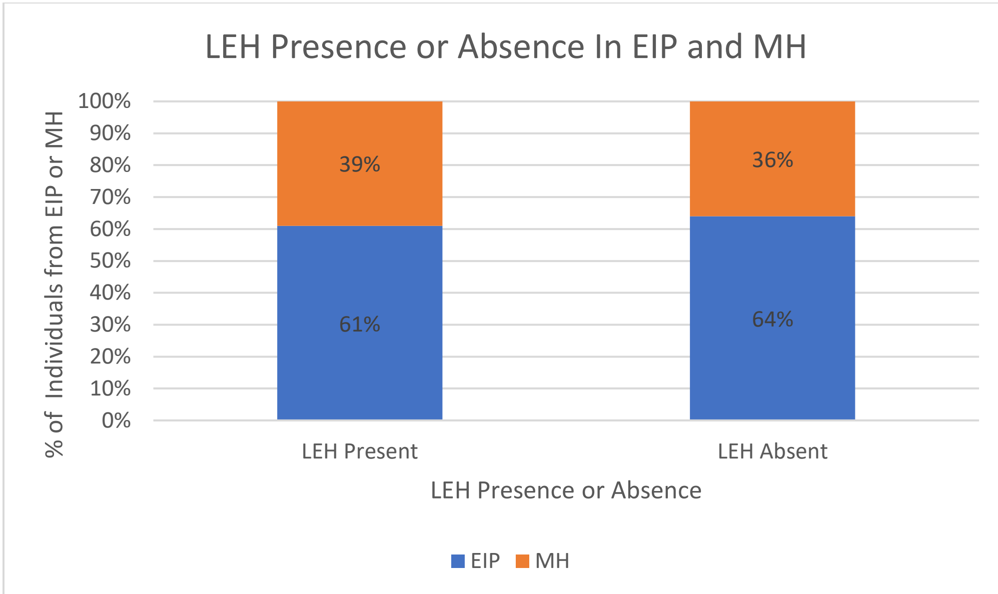

Figure B 7. Distribution of LEH between the Early Intermediate Period and Middle Horizon.

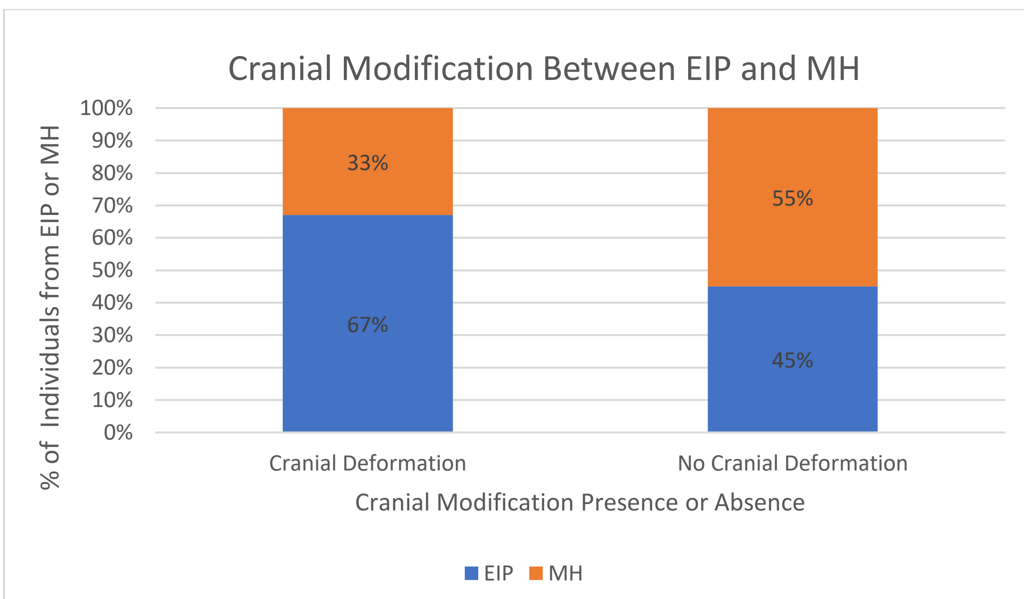

Figure B 8. Distribution of Cranial Modification between the Early Intermediate Period and Middle Horizon.

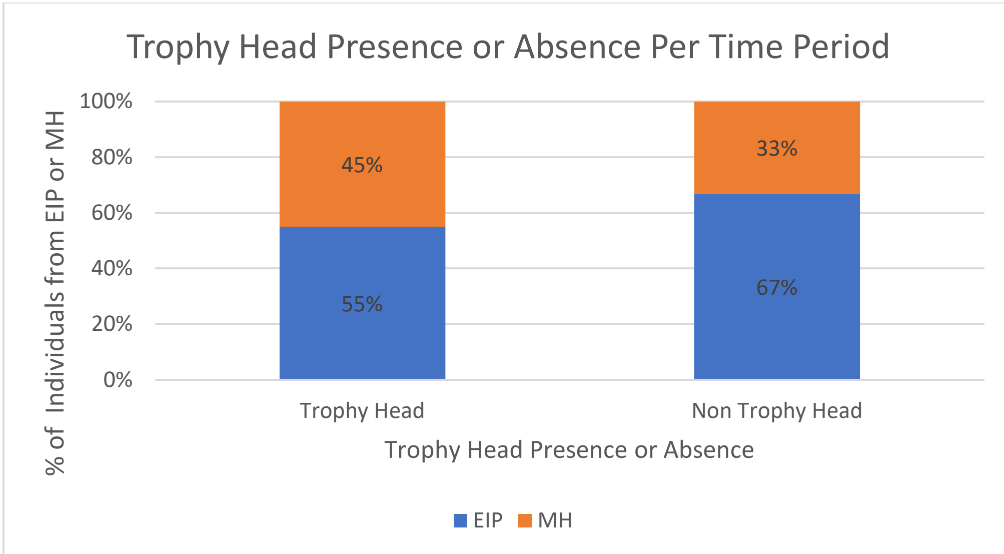

Figure B 9. Distribution of Trophy or Non-Trophy Heads between the Early Intermediate Period and Middle Horizon.

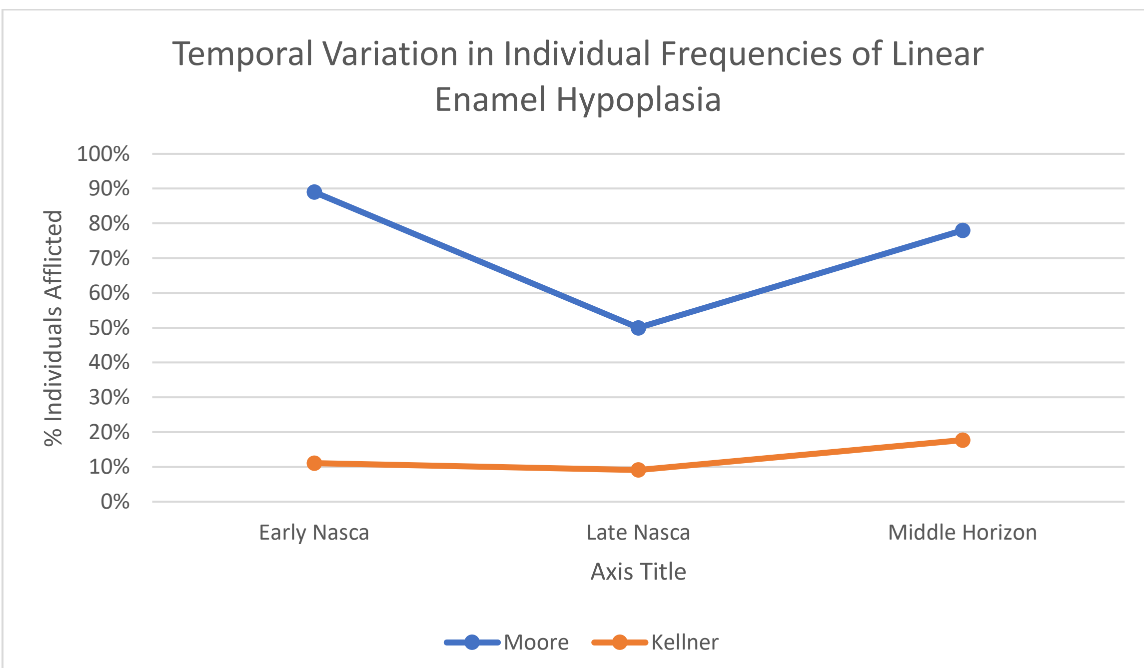

Figure B10. Temporal Variation in Individual Frequencies of Linear Enamel Hypoplasia Between Moore 2022 and Kellner 2002 Studies.