The Osteological Paradox and Issues of Interpretation in Paleopathology

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ABSTRACT

Paleopathologists identify diseases in bioarchaeological remains by the observation of skeletal lesions. However those that succumb to death shortly after contracting a disease will not show any signs of sickness on their skeleton, while those that were able to live much longer with the disease will have developed bony lesions. Due to this osteological paradox the question of a disease’s occurrence may be overlooked or misinterpreted, which in turn can lead to grandiose statements that some diseases were rare or nonexistent in ancient times. This paper examines the osteological paradox and calls for paleopathologists to adopt a biocultural perspective, looking to multiple lines of evidence as well as eliminating the perceived binary of healthy and unhealthy. It is this strict binary that led to the creation of the osteological paradox and hinders paleopathological interpretations.

Bioarchaeology concerns itself with the skeletal remains of humans in an archaeological context. This area of study is divided into many sub-disciplines that examine various aspects of the human condition as interpreted through what is seen on skeletal remains. One of these sub-disciplines is paleopathology, the study of ancient diseases. This sub-discipline examines diseases that were present in an individual at the time of death by identifying bony reactions and lesions on their skeletal and dental tissues. Initial interpretations are based on the idea that the presence of a lesion denotes that the individual had contracted a disease, while the absence of a reaction indicates health. Through these skeletal observations, paleopathologists infer whether an individual was healthy or sick.

However, Wood et al. (1992) raised the question of whether these interpretations were in fact true through the concept of the osteological paradox: health and sickness are inferred from bony lesions, yet these lesions are produced as an immune response and take significant amounts of time to form (i.e. a
chronic condition). If an individual contracted a disease that left no bony response (i.e. an acute condition), is it then reasonable for paleopathologists to claim that they were healthy? This is problematic because it calls into question the interpretations of past paleopathological cases. However, recent paleopathological research has demonstrated that this paradox can be accounted for by taking a biocultural approach which incorporates multiple lines of evidence when looking at skeletal remains from archaeological sites (i.e. Buzon and Judd 2008; Wright and Chew 1998). This paper reviews the osteological paradox and illustrates that its existence is a result of interpretations of disease that are a simple binary of healthy and unhealthy.

The Osteological Paradox

The osteological paradox, as first proposed by James Wood, George Milner, Henry Harpending and Kenneth Weiss in 1992, deduces the relative health of an individual from the presence of bony reactions and lesions within bone. If such lesions are present, then the skeleton is deemed to have been unhealthy at the time of death. Conversely, if the skeleton does not show any lesions, then the individual is labeled as healthy. Herein lays the osteological paradox: diseased individuals who lived long enough to manifest skeletal lesions were healthier than those who died of an illness before it could manifest in their skeletons (Wood et al. 1992).

In order for bony lesions to occur, an individual must live with a disease for a long period of time. Skeletal formation and reaction is a slow process; depending on the condition it can take anywhere from a year to a decade for noticeable lesions to become apparent (Roberts and Manchester 2007). As such, the osteological paradox is framed within two time points: the time of disease contraction and the time of death. If this were the case, then skeletons with lesions cannot be considered unhealthy, when in life they were able to live with the disease for many years. Following this logic, those that contracted a disease but succumbed to death in a much shorter time span would not show any skeletal lesions as there was simply not enough time for a response to occur. Therefore, while the absence of lesions does not necessarily denote absence of disease, the presence of a lesion does not necessarily indicate sickness, but instead may represent a sign of health (Wood et al. 1992).

To better understand the osteological paradox, consider the following hypothetical situation proposed by Wood et al. (1992). There is a population that consists of three subgroups each with the same potential of contracting a disease that may result in death and a distinctive skeletal lesion. Subgroup (A) never contracts the disease and thus never develops the distinctive lesions. Subgroup (B)
does contract the disease, has it long enough to develop a skeletal reaction, but there are few to no deaths. Subgroup (C) also contracts the disease but experiences it much more acutely than the previously mentioned subgroups and dies soon after, before any lesions can form. Within this hypothetical context, there exist three subgroups: two without the distinctive lesions and one with them. Upon observation of the skeletons, however, there appears to be only two subgroups instead of three: those with lesions and those without lesions. As a result, both subgroups (A) and (C) are assumed to consist of one healthy subgroup, while (B) is determined to be unhealthy (Wood et al. 1992).

Wood et al. (1992) have since been criticized for their proposal of the osteological paradox; one biological anthropologist went so far as to say they, “demonstrate the dangers of scientific snobbery” (Goodman 1993). Essentially, Goodman (1993) believes that there is no osteological paradox simply because Wood et al. (1992) fail to consider other lines of evidence. He asserts that skeletal and dental remains provide information regarding the conditions at death as well as throughout life. For example, stature and long bone measurements can be used to determine general nutritional status (Haviland 1967), while examination of the dental enamel can indicate periods of nutritional stress during the time of tooth mineralization in childhood (Rose et al. 1985).

In regards to the hypothetical example of the paradox provided by Wood et al. (1992), Goodman (1993) points out that not all of the information available was utilized in a meaningful way. Recall that subgroup (B) was determined to be unhealthy because of the presence of skeletal lesions while subgroup (C) was assumed healthy due to the lack of lesions and consequently joined with subgroup (A). Also, keep in mind that the disease within this hypothetical population had equal probability of infecting any individual. Since disease is indiscriminate in regards to who is infected, all age groups had an equal chance of contracting the illness, including children. Since subgroup (C) did not survive the disease in question, then there would be a greater distribution of ages within the collection of “healthy” skeletons. The “unhealthy” subgroup (B) would not have any juvenile remains because although children might have contracted the disease, they would have lived into adulthood and developed the same characteristic lesions as the other adults in their subgroup. Surely, the high prevalence of juvenile skeletons among the “healthy” subgroup would have raised questions among bioarchaeologists. While this may not easily separate subgroup (C) from (A), it does provide one possible way to identify some members of the otherwise unidentifiable subgroup (C) (Goodman 1993).

Furthermore, if members of all subgroups had an equal risk of contracting a disease and subsequently dying from it, then it is expected that the skeletal assemblage would be representative of the living population. Wood et al. (1992) showed that this is improbable as (C) was quick to die while (A) was able to live.
In these subgroups, different factors (i.e. immune response, access to health care, etc.) will play a part in whether the individual dies or lives. Cohen (1994) also points out that not all deaths within a group occur due to similar reasons or causes. In regards to the subgroups, disease is not the only cause of death among humans. Even if in subgroup (C) there is a higher chance of dying from the disease in question, there is always the possibility that something else will lead to death even sooner. In this regard, it is not correct to assign the status of healthy to an unhealthy individual who died of another factor. This leads to an issue of interpretation within paleopathology, as researchers are basing their diagnoses within a simple binary of healthy and unhealthy. The presence or absence of skeletal lesions informs the researcher of the individual’s health at time of death but it cannot easily imply whether that individual was healthy or unhealthy throughout their life.

**Addressing the Osteological Paradox: a Biocultural Approach to Paleopathology**

If, in fact, there is no osteological paradox as Goodman (1993) asserts, and analyses are to be made on multiple lines of evidence, then a biocultural approach would be best as it deals with disease as both a biological entity, which has specific effects on the body, as well as a cultural entity with complex social repercussions (Roberts 2000). With the blending of biology and culture, disease can be better understood. Furthermore, the biocultural approach is a holistic tradition within anthropology, which benefits from each of the subfields. Paleopathology does not have to restrict itself to purely biological anthropology, but can also examine disease through the lenses of cultural anthropology and archaeology. Methods that have been proposed as other lines of evidence in paleopathological interpretations include DNA analysis, paleohistology, paleoepidemiology, differential diagnosis, comparative analysis, and the examination of historical and archaeological data.

Since 1992, when the osteological paradox was proposed, there have been significant scientific advances in DNA analysis and paleohistology. With regards to the former, researchers are now able to identify the pathogenic DNA of diseases in ancient remains (Donoghue et al. 2004; Papagrigorakis et al. 2006; Zinc et al. 2000). Although this technique is expensive and destructive, these advances also give rise to the possibility of identifying pathogens in skeletal remains that do not show any bony response (Wright and Yoder 2003: 54). Paleohistology, conversely, is a method that enables the paleopathologist to inspect diseases on bone at the microscopic level. For instance, bony lesions can be examined for signs of cellular healing (Wright and Yoder 2003) as well as
necrosis in response to the presence of a pathogen. In either case the process of healing or formation of a lesion on bone may have been occurring but stopped at the time of death before its effects could be seen at a macroscopic level.

Paleoepidemiology is a subfield within biological anthropology and has been promoted by scholars as a companion for paleopathological research (Cohen 1994; Goodman 1993; Wright and Chew 1998; Mendoça de Souza et al. 2003). Defined as “the study of the factors affecting the distribution of health and illness of past populations, with the population, rather than the individual, being the unit of study” (Lovell 2008: 348), paleoepidemiology recognizes that diseases are a result of complex interactions between people and their social/natural environments, as well as looking at the causes of disease and its dynamics within a group. This line of inquiry also focuses on the group and not the individual (Goodman 1993).

Aside from the above mentioned, the most highly advocated method in paleopathology has been differential diagnosis. Cohen put it best when he said, “each pathology is telling us something of its own character and the lifestyle of its victims by its pattern in the skeletons” (1994: 631, emphasis added). This is an effective reminder to the paleopathologist that it must be acknowledged that the presence of a lesion could be a result of more than one disease. The human skeleton is shaped by the accumulation of life-history experiences which include multiple factors that are not limited simply to illness; foods eaten and activities that have been pursued all become comprised in bone tissue over time (Agarwal 2012). Also, researchers must pay attention to the type and distribution of lesions on the skeleton and make their diagnoses attributable to at least a general category of disease such as: infectious, dental, congenital, neoplastic, metabolic, or traumatic. Though at times it may not be possible to even establish one of these basic disease categories, this general information does help in the interpretation of the health of past populations (Ortner 2008).

In relation to differential diagnosis is the method of comparative analysis. Agarwal (2012) argues that populations can have different patterns of lesions and bony reactions due to the distinctiveness of their biosocial environment, in other words based on their biocultural experiences. However, bone is limited in the number of ways it can respond to an infection, and therefore, different biosocial environments and different diseases can cause similar lesions in the skeleton. In order to aid differential diagnosis, comparative analysis is useful in comparing skeletal lesion characteristics from neighbouring archaeological sites to help identify the causative pathological conditions. Modern skeletal collections are also a viable option for comparative research as they consist of documented cases with known diseases, as well as information regarding sex, age, and ancestry (Kelley 1982; Judd 2004).
Historical and ethnohistorical written accounts can also be an invaluable resource for the paleopathologist as writings of the time might give some insight in regards to the state of health and sickness being experienced by the population. These accounts could also have descriptions or illustrations of diseases and symptoms that were apparent in the soft tissue – a perspective that does not survive in the bioarchaeological record. However, it should be warned that these sources could contain or introduce cultural, historical or socioeconomic biases, which can influence the accuracy of such accounts. Ethnographic research of modern populations can also provide an analogy with which to interpret health in the past, if a clear connection between modern and archaeological peoples can be established (Wright and Chew 1998). Furthermore, the burial practices of individuals can be of significance as well. Perhaps the burial site is different from what is culturally expected (i.e. position of the body, grave markers, etc.) or the placement of different grave goods can be interpreted as a protection for the living from the dead (Sledzik and Bellantoni 2005). The graves could also have had a chemical agent added to the soil such as lime, which was intended to speed the process of decay (Bianucci et al. 2008). Consideration of these factors and practices, whether they be cultural in nature or not, can further paleopathological studies and lead to more in depth interpretations about health in the past. This approach also takes away from the simplistic healthy/unhealthy binary by showing that the concept of what makes a person healthy or unhealthy has cultural variability.

The Osteological Paradox in Practice

Since Wood et al. (1992) presented the osteological paradox to the archaeological community other scholars have since provided real life examples of where the paradox can be seen. For instance, Steckel et al. (2002) compare the mid-19th century skeletons of a poorhouse in Rochester, New York (Higgins et al. 2002) with those of contemporary middle-class Episcopalians from Belleville, Ontario (Saunders et al. 2002). When examining these two groups for pathologies, the first expectation would be that the skeletons of the poor would show signs of infection. However, these skeletons had fewer lesions than those of the middle-class (Steckel et al. 2002). Following the paradox, it is reasonable to conceive that the poor were unable to seek proper medical attention and thus mortally succumbed to disease rather quickly. In the case of the middle-class, health care was readily available, which allowed individuals to heal or live with a chronic condition for many years.

Another example of the paradox was found among the ancient Maya. Due to the high frequencies of porotic hyperostosis (a type of skeletal lesion that is characteristic of anemia) found amongst ancient Maya crania, it has been
suggested by bioarchaeologists that ancient Mayan children suffered from extremely poor nutrition (Wright and Chew 1998). This notion was reconsidered when forensic crania of modern adult Maya skeletons from rural Guatemala were examined. Wright and Chew (1998) demonstrate that anemia was still prevalent among rural children, as the Guatemalan government had undertaken a national survey of the metabolic disease around the same time of the death of the modern individuals. Surprisingly, the modern crania did not show the same level of porotic hyperostosis as those of the ancient Maya (Wright and Chew 1998). Wright and Chew (1998) concluded that although the children of the ancient Maya had higher frequencies of porotic hyperostosis, they were better able to grow into adulthood and develop the characteristic lesions. The modern population, on the other hand, which the national government’s survey determined to have a high prevalence of anemia, had a much higher mortality rate than their ancestors and thus did not develop lesions. The lower frequencies of porotic hyperostosis would appear to indicate a lower prevalence of anemia among the modern Maya, when in fact it may be that unhealthy individuals, in this case those who experienced childhood anemia, were more susceptible to death at earlier ages and thus did not survive to exhibit healed lesions as adults.

The last example of the osteological paradox was found among the human sacrifices at the ancient city of Kerma, in what is now Egypt and Sudan (Buzon and Judd 2008). Initially excavated in 1907, the leading archaeologist claimed there was evidence of human sacrifice due to the spatial relations of the entombed (Reisner 1923). Bioarchaeologists have since questioned this interpretation and hypothesized that if these individuals were indeed sacrificed, they would be healthier because they did not die naturally. The reasoning follows that non-sacrificed individuals would have died of natural causes including infections, trauma, epidemics or chronic conditions while sacrificial victims died at a time when they may or may not have been healthy (Buzon and Judd 2008). When the sacrificed and non-sacrificed individuals were compared in terms of pathological stress, the researchers found that there were no statistically significant differences. In fact, skeletons of either group were quite similar in regard to the presence of bony lesions (Buzon and Judd 2008). In light of these findings, Buzon and Judd (2008) offered an alternative interpretation, arguing against the assumption that sacrifice was being practiced. In this case, the osteological paradox was applied in a slightly different way: healthy was replaced with sacrificed, while non-sacrificed meant being unhealthy. In other words, non-sacrificial victims would be healthier as they succumbed to a natural death while sacrificial victims would not. Like the victim of a fast acting plague, sacrificial individuals died quickly before bony lesions had the opportunity to form in response to a disease. The non-sacrificed on the other hand, were allowed to live on, die of natural causes, and possibly exhibit a bony response from a disease contracted later in life. While the
authors did not find a paradoxical relationship related to sacrificial status, this study illustrated the benefits of using a biocultural approach that combines data from a variety of sources to not only explore health factors but also assess assumptions made about the health status of individuals buried at archaeological sites (Buzon and Judd 2008).

The Implications for Interpretations in Paleopathology

With their proposal of the osteological paradox, Wood et al. (1992) called for paleopathologists to consider alternative explanations for lesion frequencies in their data. Although researchers challenged the relevance of the osteological paradox (Cohen 1994; Goodman 1993; Jackes 1993), their discussion encouraged paleopathologists to incorporate a biocultural model that emphasizes the use of multiple lines of evidence in their research.

However, the reason the osteological paradox came into being was as a result of the underlying binary of healthy and unhealthy that has influenced paleopathological research and has since challenged how interpretations are influenced. For instance, since bone can respond to an infection in a limited number of ways there is a chance that an individual might have more than one disease presenting itself in their skeleton (Ortner 2008). Also, since the skeletal material is limited in its representation of what occurred in life, the paleopathologist must at times concede to the prospect that a diagnosis is simply not possible. This may occur for a number of reasons, such as the lesions may be too small to be identified or the researcher simply cannot identify what kind of disease caused them. Also, a chronic infection can affect the skeleton, but its manifestation usually occurs in only a relatively small percentage of individuals with the disease (Ortner 2008). In addition, different interpretations of the data and supporting evidence can be used to advance some interpretations or denounce others (Pinhasi and Bourbou 2008). While keeping all of this in mind, paleopathologists must always call into question the accepted interpretations of bioarchaeological data. Like all archaeological data, paleopathological research can be what Hauser (2011) calls “messy,” but it should not be seen as a limitation to interpretation. Instead, it should be embraced and seen as a chance to be left open to a realm of possibility that at the present cannot be fully explored.

Finally, this binary of healthy and unhealthy must come to an end as it traps the paleopathologist in an over-simplified view of disease. However, with the application of a biocultural approach through the use of multiple lines of evidence, our understanding of disease in the past is now more complex. As such, paleopathologists can no longer simply say that the presence of a lesion always infers disease and the absence of a lesion always infers health. Also as with other binaries there is overlap in what can be called healthy and what can be called
unhealthy. But there is never a case in which a definitive position can be taken on either side of this spectrum. The existence of the osteological paradox is dependent on this simple binary of unhealthy and healthy based on the presence or absence of pathological lesions in the skeleton.

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