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# Human Health and the Neolithic Revolution: an Overview of Impacts of the Agricultural Transition on Oral Health, Epidemiology, and the Human Body

Katherine J. Latham

*Abstract: The transition from a hunter-gatherer lifestyle to dependence on agricultural production is commonly considered one of the most important achievements of human history. This transition, often referred to as the Neolithic Revolution, ushered in a variety of changes in human dietary intake, food processing and procurement methods, settlement patterns, and physical activity. Skeletal analyses of human remains from early agricultural centers throughout the world indicate that this revolution significantly affected overall human health. This paper will address some of the drastic effects of this transition as evidenced by craniofacial changes related to masticatory function, declines in oral health, increased spread of pathogens, infectious disease, and zoonoses, as well as a variety of ailments which have been linked to nutritional deficiencies and increased physical stress on the human body.*

For the majority of our history, humans lived a nomadic lifestyle as hunter-gatherers. Near the beginning of the Neolithic, about 12,000 years ago, humans adopted a more sedentary lifestyle and gradually transitioned to a fully agricultural subsistence economy (Larsen 2006; Ulijaszek 1991). This drastic change of diet and lifestyle had a dramatic effect on the overall health of Neolithic humans.

Teeth are directly affected by diet and are a good source of information on the ways in which the dietary and food processing changes associated with the beginnings of agriculture impacted the general health of Neolithic peoples (Tayles et al. 2000). By analyzing teeth from Neolithic samples, paleoanthropologists have observed a general trend of declining oral health among Neolithic people in

comparison to their hunter-gatherer predecessors. The advent of agriculture is associated with the reduction of tooth size, crowding, increases in caries, and increased occurrence of periodontal disease.

Archaeological evidence suggests that humans adopted new ways of processing food during the Neolithic which included the use of grinding stones and cooking in ceramic vessels (Larsen 2006; Meller et al. 2009). This is supported in Neolithic samples by a pattern of decreased skull size and shape and dental microwear evidence (Larsen 2006; Sardi et al. 2004). Bone responds to high amounts of physical activity and stress by increasing in mass (Larsen 2006:16). Paleolithic hunter-gatherers likely had larger skulls than Neolithic peoples due to their more mobile and active lifestyle (Sardi et al. 2004). "It is accepted that masticatory forces regulate craniofacial growth and the stress is mainly due to the food consistency that causes variations in the mastication movement" (Sardi et al. 2004:141). This means that facial structures are suited to individual chewing needs. When new preparation and processing methods were introduced, foods became softer and easier to chew. Over time this change in masticatory function contributed to an overall "gracilization" of the human skull and resulted in a smaller human face with reduced jaws and teeth (Larsen 1991, 2006; Sardi et al. 2004). Reduction of the face negatively affected human oral health because human teeth did not reduce proportionately to the jaw and crowding resulted (Larsen 2006).

Dental crowding is problematic because it creates tight spaces between the teeth where bacteria can easily grow. These oral bacteria can contribute to plaque build-up and promotes caries, "an oral infectious disease [which] involves the demineralization of the enamel and the underlying dentin and other tissues, caused by the acids produced as a byproduct of the metabolism of dietary carbohydrates, especially sugars" (Larsen 2006:13). Increased occurrence of caries has generally been associated with agricultural lifestyles; however, a study in southeast Asia conducted by Taves et al. (2000) found that caries decreased with the introduction of rice agriculture, suggesting that rice may be less cariogenic than other starchy staple foods which formed the subsistence base of other Neolithic cultures (Meller et al. 2009).

Similarly, Papathanasiou (2005) found that dental caries were present in low frequencies among the early agriculturalists of Alepotrypa Cave in Greece. Eshed et al. (2010:383) found a decrease in caries among the Neolithic of the Levant. According to Meller et al. (2009:290), the maize-based diet associated with many prehistoric American agriculturalists was "rich in sticky carbohydrates and sucrose... thereby, the physical and chemical properties of maize, probably combined with its preparation methods, seem to provide a

cariogenic potential in the oral environment.” In the Americas there is a clear relationship between maize-based agriculture and increased occurrence of caries (Larsen 1991; Meller et al. 2009; Tayes et al. 2000).

Microwear analysis suggests that the new food processing methods of the Neolithic combined with consumption of softer foods may have contributed to caries as well as attrition. “Microwear is displayed as pits and scratches on the teeth. The expression of these features is determined by the consistency of the foods consumed and/or the inclusion of extraneous particles introduced to the food when it is being prepared” (Larsen 2006:13). These “pits and scratches” create environments for cariogenic bacteria. When coarse foods are eaten regularly it wears down the microwear on teeth and helps prevent caries, but when softer foods are eaten the bacteria has an opportunity to thrive in these spaces (Meller et al. 2009). Residue from stones used to grind plant matter and, in dry environments, sand incorporated into foods, have been attributed to promoting caries as well as attrition in Neolithic populations in both the Old World as well as the Americas (Larsen 2006; Meller et al. 2009; Papathanasiou 2005).

While caries increased most markedly among the maize-based cultures of the Americas, populations of the Old World also saw a decline in oral health. Papathanasiou (2005) cited increases in pre-mortem tooth loss and periodontal disease among the early Greek agriculturalists from Alepotrypa cave. Periodontal disease, also known as gingivitis, can cause tooth loss and serious damage to the tissue and bone supporting the teeth (Larsen 2006; Papathanasiou 2005). Meller et al. (2009) reported similar findings among the Pica-Tarapaca culture of the Atacama Desert circa 1000 B.P. as well as among the Maya of Mexico. Eshed et al. (2010) cited a decrease in attrition and periodontal disease in the Levant but reported increased occurrence of calculus (tartar or plaque).

Hunter-gatherers maintained much smaller populations than early agricultural communities. Due to a diverse diet and smaller group numbers, hunter-gatherer societies had less potential for nutritional deficiencies and infectious diseases (Armélagos et al. 1991). With the advent of a sedentary agricultural lifestyle, Neolithic populations dramatically increased (Larsen 2006). Skeletal analysis suggests that these Neolithic peoples experienced “greater physiological stress due to under nutrition and infectious disease” (Ulijaszek 1991:271).

Cities and other large settlements appeared for the first time during the Neolithic. Pathogens require a large host to thrive and these large, crowded populations provided a human host population that had

not previously existed among hunter-gather societies (Armélagos et al. 1991:15). Now able to spread easily from person to person in the crowded conditions of cities, pathogens were able to exploit entire groups and reach endemic levels (Armélagos et al. 1991; Papathanasiou 2005).

Crowded conditions paired with human settlements in close proximity to animals also contributed to high rates of infectious disease. In many early agricultural communities, animals were kept both near to and inside of houses. This proximity allowed some zoonotic diseases to transfer from animals to humans (Armélagos et al. 1991; Eshed et al. 2010). Contaminated water sources and close contact with human waste also facilitated parasitic infection in both animals and humans (Armélagos et al. 1991; Larsen 2006; Papathanasiou 2005).

The increase of infectious disease associated with the adoption of an agricultural lifestyle did not necessarily increase mortality (Eshed et al. 2010). Those most likely to suffer fatal infections would have been infants, young children, and the elderly. Individuals who reached reproductive age had likely developed a resistance to such diseases (Armélagos et al. 1991). However, it must be noted that nutritional deficiencies can reduce resistance to infections which can further contribute to nutritional deficiencies (Armélagos et al. 1991; Larsen 2006). This interplay between nutrition and disease can increase mortality in populations and inhibit an individual's ability to work and/or reproduce (Goodman 1993).

Many early agricultural centers were dependent upon one to three crops and ate significantly less meat than their hunter-gatherer predecessors (Armélagos et al. 1991; Eshed et al. 2010; Papathanasiou 2005). Cereals such as barley, wheat, and millet, as well as rice and maize, commonly formed the subsistence base of early agricultural communities. Decreased variety of food also meant a decreased variety of nutrients in the diets of these people. Cereals contain little iron, but do contain phytates which are known to inhibit iron absorption (Papathanasiou 2005). "Maize is deficient in amino acids lysine, isoleucine, and tryptophan. Moreover, iron absorption is low in maize consumers, and... rice is deficient in protein which inhibits vitamin A absorption" (Larsen 2006:15). Larsen (2006) further suggests that dependence upon plant foods over meat reduces the intake of zinc, vitamin A, and vitamin B12 which are only available in animal foods.

Evidence of infectious disease and nutritional deficiencies is found in Neolithic skeletal samples as skeletal lesions in the form of porotic hyperostosis and cribra orbitalia. According to Uliaszek (1991:272), "porotic hyperostosis has been reported to be present in

skeletal remains from the Neolithic onward.” Porotic hyperostosis appears on the skeleton as a thick, sponge-like lesion. Cribra orbitalia is a kind of porotic hyperostosis which occurs on the skull. Both conditions are associated with anemia (Eshed et al. 2010; Larsen 2006; Papathanasiou 2005; Ulijaszek 1991). Anemic conditions which contribute to porotic hyperostosis can occur as a result of iron or ascorbic acid deficiencies, dietary deficiency, infection, or a combination of these factors (Eshed et al. 2010; Larsen 2006; Papathanasiou 2005; Ulijaszek 1991).

Ulijaszek (1991) created a model of nutritional intake for both pre-agricultural hunter-gatherers and Neolithic men in an attempt to understand the relationship between diet and the frequent occurrence of porotic hyperostosis in Neolithic communities of the Mediterranean and the Near East. Results from this model suggest that iron deficiency anemia due to nutritional deficiencies alone would only occur if the individual was already suffering from chronic energy deficiency (CED) (his weight was low for his height). The author suggests that in the Near East and Mediterranean, porotic hyperostosis can be attributed to infection from intestinal parasites, at least among those who were not already suffering from chronic malnutrition (Ulijaszek 1991).

Prevalence of anemia and porotic hyperostosis is known to have increased dramatically in the Americas. This is likely due to the low amount of iron provided in a maize-based diet (Eshed et al. 2010). At Alepotrypa cave in Greece, Papathanasiou (2005:382) found that cribra orbitalia was present in more than 60% of skeletons analyzed but the condition was only mild in most cases. Papathanasiou conducted paleodietary analysis on this sample and the results suggest that iron deficiency due to malnutrition was to blame; however, she did not rule out the possibility that this nutritional deficiency was accompanied by parasitic or bacterial infection (Papathanasiou 2005).

Transitioning from a hunter-gatherer-based subsistence economy to an agricultural lifestyle not only changed the foods Neolithic peoples consumed, it also changed their workloads. It has been suggested that the hunter-gatherer lifestyle is more physically demanding than an agricultural lifestyle (Larsen 1981). Skeletal analysis suggests that gender-based labor divisions also changed when humans adopted agriculture (Larsen 1981; Eshed et al. 2010). These changes in physical stress on the skeleton as well as nutritional deficiencies likely contributed to an overall reduction in stature following the transition to agriculture (Eshed et al. 2010; Larsen, 1981 2006; Papathanasiou 2005; Ulijaszek 1991).

A general trend of decreased stature reflects an overall decrease in health among agricultural populations of the Neolithic.

According to Goodman (1993:283), “stunting on a group level is often a sign of a growth-sparing response to environmental conditions.” Growth stunting can be indicative of undernutrition due to malnourishment and high exposure to disease (Goodman 1993).

Evidence of stunted growth can be seen on teeth in the form of enamel hypoplasia and on the skeleton in the form of growth arrest lines as well as osteopenia and osteoporosis (Goodman 1993; Larsen 2006; Papathanasiou 2005). High occurrence of enamel hypoplasia has been reported along with decreased stature at the Dickson Mounds early agricultural site in Illinois and in the Levant (Eshed et al. 2010; Goodman 1993). Occurrence of both growth arrest lines and osteopenia on long bones have been reported in high numbers among Neolithic samples from Greece and the Near East (Papathanasiou 2005; Ulijaszek 1991).

Osteopenia and osteoporosis can occur as a result of malnutrition during childhood and impact overall adult height. Osteopenia and osteoporosis are generally associated with calcium deficiencies but can also result from deficiencies of vitamin D (Ulijaszek 1991). Neolithic peoples did not use domestic animals for milk until the end of the Neolithic, so early agriculturalists would not have had access to calcium or vitamins from dairy products and plant foods are not good sources of calcium. Even though skeletal evidence suggests that early Neolithic peoples were deficient of both calcium and vitamin D, it is not likely that diet alone contributed to calcium deficiencies as osteoporosis is not observed at the same rates among pre-agricultural societies (Ulijaszek 1991). These deficiencies combined with the effects of infectious disease during childhood likely stunted growth and contributed to the occurrence of osteopenia and osteoporosis (Ulijaszek 1991).

As previously discussed, bone responds to stress and “greater activity results in more bone development than lesser activity” (Larsen 2006:16). It is thought that the agricultural lifestyle is less demanding than the lifestyle of hunter-gatherers. If this is true, then we would expect to see overall stature decrease in response to activity decreases. Decreases in activity can be assessed by comparing the occurrence of osteoarthritis in pre-agricultural and early agricultural communities. Larsen (1981) associated decreased occurrence of osteoarthritis with decreased economic activity among the early agriculturalists of coastal Georgia. This was not true of the peoples of the Levant, however, and Eshed et al. (2010) have shown that arthritic lesions associated with stress were more common in men and might reflect changes in gender based divisions of work following the transition to agriculture. This idea is supported by Larsen (1981:422), who noted a greater decrease

in stature among females in coastal Georgia and cited ethnohistoric data which suggests that “males did all of the hunting and females were responsible for agriculture related activity.”

The transition to agriculture in the Neolithic was arguably one of the most drastic lifestyle changes in human history. Changes in diet, living conditions, and subsistence activities had an enormous impact on human health, though effects varied from region to region. Skeletal analysis of these early agricultural communities suggests that the transition to agriculture had an overall negative impact on human oral health, increased the incidence of infectious disease and nutritional deficiencies, and contributed to an overall reduction in human stature.

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