THE ARCHAEOLOGY OF OBESITY: DISCOURSE ANALYSIS AND IMPLICATIONS FOR NORTH AMERICAN OBESITY RESEARCH

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CERTIFICATION OF APPROVAL

I certify that I have read The Archaeology of Obesity: Discourse Analysis and Implications for North American Obesity Research by Laura Yadira Maldonado, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Arts in Anthropology at San Francisco State University.

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This thesis uses an archaeological analysis to transcend the medicalized and moralized discourses surrounding obesity while advancing knowledge on the stigmatization of fat. Archaeological analysis of obesity includes analysis of body mass estimation techniques, associated skeletal pathologies, and visual representations of fat and obese bodies. Two case studies that focus on associated pathologies in Pre-Columbian North America include Smith and colleagues' identification of diffuse idiopathic skeletal hyperostosis (DISH) in Tennessee and Mulhern and colleagues' analysis of hyperostosis frontalis interna (HFI) in New Mexico. Future studies on these samples should incorporate body mass and stature estimation in order to analyze the variation in body size within these populations. The application of critical discourse analysis will also inform how societal discourses influence perceptions on body size and fatness, and this methodology also aids in identifying the problematic social injustices that result from the biased perspectives of academic scholars.

I certify that the Abstract is a correct representation of the content of this thesis.

pp Cynthia A Wilczak

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I would like to dedicate this thesis to my parents Jesus and Laura Maldonado. None of my academic or life achievements would have been possible without your unconditional support, and I am forever grateful for having such wonderful and encouraging parents as yourselves. Thank you.

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Chapter 1: Introduction

The purpose of this thesis is to identify the advantages and limitations of an archaeological analysis of obesity with the intent of applying these methods to expand knowledge on obesity discourse in North America. Western countries such as the United States of America have experienced a dramatic rise in obesity rates within recent decades, which is a phenomenon commonly referred to as an obesity epidemic. Increases in national weight averages have influenced societal ideologies regarding fat and obese bodies, and historical analyses of obesity in the United States indicate that societal discourses have become increasingly critical and often discriminatory against obese bodies. While academic research predominantly focuses on obesity issues in contemporary contexts, I propose that an archaeological analysis of obesity will produce supplementary knowledge that will advance current understandings regarding the stigmatization of fat and obese bodies.

Existing literature prioritizes the analysis of obesity statistics and trends within contemporary Western societies. However, an analysis of archaeological materials from various chronological periods and geographic regions will contribute to obesity research by demonstrating how shifting social values influence societal perspectives on body fatness and obesity. An archaeological analysis of obesity will require an examination of body mass estimation techniques, associated skeletal pathologies, and visual representations of fat and obese bodies in prehistoric and ancient contexts. The objective of this thesis is to explain these direct and indirect approaches while also utilizing critical discourse analysis in order to examine 1) the advantages and limitations of methods used to study obesity in archaeological contexts, 2) how societal and academic discourses alter perceptions on fatness and obesity through processes of idealization, moralization, and medicalization, and 3) the problematic social injustices that result from biased perspectives of academic scholars.

In order to understand the benefits of an archaeological analysis of obesity, the first portion of this introduction will detail the current state of obesity research. This section elaborates on the excessive focus academia places on obesity statistics and prevalence trends in the United States. Furthermore, I argue that obesity research should incorporate an archaeological perspective in order to identify how biological, social, and ecological factors affect the societal values placed on body fatness. The second section provides a brief history of obesity in the United States, which serves to exemplify the shift and stigmatization of body fatness within a Western population. The last section of the introduction will provide an overview and brief description of each thesis chapter. Following this introduction will be a section detailing the advantages in using critical discourse methodology to study obesity in archaeology. The final section of this chapter will briefly review the literature that inspired this topic and introduced major themes relating to obesity and fat stigma.

Obesity Research

Academic research commonly focuses on statistical obesity trends in order to emphasize the medical and economic consequences of obesity. The standard definition for obesity describes this physical condition as an exhibition of excess adipose tissue that results in a body mass index (BMI) greater than 30 kilograms/meters^2 (Gallagher et al. 1996: 228; O'Rahilly and Farooqi 2006: 1097; Tsai et al. 2011: 51). According to surveys conducted by the National Institutes of Health, obesity rates have significantly increased among adults and children in the United States since 1980 (Nguyen and El-Serag 2010: 4). The National Center for Health Statistics reports that approximately 37.5% of adults in the United States were clinically obese between 2011-2014 (Ogden et al. 2015: 1). Based on obesity prevalence data collected by the National Health and Nutrition Examination Study, researchers predict that approximately 51.1% of American adults will be diagnosed as obese by 2030 (Wang et al. 2008: 2326). Compared to normal weighted Americans, obese Americans make approximately 33% more visits to primary care physicians (Bellisari 2016: 24), and they also spent a minimum of $1,723 yearly in additional per capita medical costs in 2008 (Tsai et al. 2011: 59). It is also estimated that the 2008 national costs of medically treating obesity in the United States was approximately $98.1 billion (Tsai et al. 2011: 56).

These intimidating statistical trends frame obesity as a major societal concern with dire economic consequences (Townend 2009: 174; Nguyen and El-Serag 2010: 4). The national cost for treating obesity will continue to rise unless effective preventative measures are established. Successful prevention strategies will often target specific groups of people who experience high obesity rates, as obesity increases in prevalence according to sex, age, and ethnic groups (Wang et al. 2008: 2326; Ogden et al. 2015: 5). Obesity prevention strategies are observed to decrease the use of healthcare services and expenditure in the United States, and the long-term economic savings are predicted to be substantial (Cecchini and Sassi 2015: 772). The emphasis that researchers place on obesity prevention strategies promotes moralized discourses that identify fat and obese bodies as detrimental to society.

Controversy persists regarding the methods used to measure and define obesity. Critics argue that increasing obesity rates are over-dramatized and based on arbitrary changes in BMI standards established by the National Institutes of Health in 1998 [see chapter 2] (Guthman 2013: 268; Raisborough 2016: 57). Researchers have also criticized the utilization of obesity as a reliable indicator of human health. Early researchers defined obesity as an excess of fat that is harmful to human health (Ofei 2005: 98; Kirchengast 2017: 29). This broad definition illustrates the stigmatization of fat as an unhealthy substance, and other researchers have avoided linking fatness with health by simply defining obesity as an excess of fat (Longhurst 2005: 249; Cabler et al. 2010: 481; Forth 2014: 11; Raisborough 2016: 22). Obesity literature generally prioritizes a medical perspective, which is advocated to be unbiased and based on scientific data. Clinical discourses function to make physical diseases comprehensible to researchers, yet the medicalization of obesity fuels fat stigmatization by promoting discourses that reproduce dominant modes of knowledge (Murray 2007: 366; Daneski et al. 2010: 738; Hill 2011: 3; Raisborough 2016: 5-6). Medical discourses also incorporate moralized perspectives on fat. Bodies that deviate from socially acceptable body sizes are pressured into corrective processes such as diet restriction and increased exercise (Vigarello 2013: 27). Inability to achieve fat loss is indicative of a gluttonous and lazy individual, and these ideas promote the stigmatization of fat bodies in contemporary Western societies.

Perception is a knowledge-making process, and perceiving obesity as a medicalized concept associated with health promotes the marginalization and discrimination of fat bodies (Puhl and Brownell 2003: 213; Murray 2007: 367; McCullough and Hardin 2013: 2). A recent movement that challenges medical discourses surrounding fat bodies is the Health at Every Size approach, which provides an alternative perspective that describes human health and body weight as concepts that are independent from each other (Guthman 2013: 271; Penney and Kirk 2015: e39). Groups such as the National Association to Advance Fat Acceptance (NAAFA) have also emerged with the purpose of reclaiming the term “fat” from the negative connotations that resulted from the processes of moralization and medicalization (Longhurst 2005: 250). Medical analyses of obesity also often omit reference to the variation in cultural values ascribed to fat (Pollock 1995: 357). Lack of cultural analyses disregards the possible social aspects that contribute to the stigmatization of body fatness among various populations.

This thesis contributes to academic debates by arguing that an archaeological analysis of obesity will benefit current understandings of fat stigmatization by analyzing how biological, ecological, and sociocultural factors inform societal discourses. An archaeological analysis of obesity will also incorporate non-western and non-contemporary societal discourses, which are perspectives that current obesity research often overlooks. Analyzing the medicalization and moralization of fat bodies also demonstrates how current obesity research reproduces dominant western modes of knowledge.

The History of Obesity in the U.S.

Attitudes towards fat and obese bodies have become increasingly critical in contemporary Western societies. However, historical analyses of obesity in the United States provide further insight on how shifting social ideals influence the stigmatization of fat bodies. While current societal discourses on fat bodies are primarily negative, fatness was regarded as a positive physical attribute due to its association with social status and class position in early nineteenth century America (Longhurst 2005: 250). Societal discourses during the Victorian period (1837-1901) revered rounded fat bodies, and wealthy individuals would feast on multiple-course meals with the intention of achieving a larger body size (Cassell 1995: 425; Bilton 2012: 55). Dining on multiple course meals also reinforced the idea that over-indulgence and fatness are linked with power and access to resources (Vigarello 2013: 5). Fat men were regarded as prominent and admired members of American society, and popular clubs devoted to fat admiration emerged such as the Fat Men's Club of Connecticut, the Heavyweights of the State of New York, and the Fat Men's Association (Mikkelsen 2003: 111; Kolata 2008: 73; Bilton 2012: 55). While American society associated fat bodies with high social and class status, critical attention was generally aimed at curing skinny people of malnutrition, as thinness was widely associated with reduced access to food resources and poor health (Bilton 2012: 55).

Negative perceptions of fat bodies gradually emerged during the mid-nineteenth century. Public authorities such as the Presbyterian minister Sylvester Graham (1794-1851) began to moralize obesity by associating it with the sin of gluttony (Cassell 1995: 425). Fat bodies were disassociated with ideas of prosperity and contentment; instead, fat bodies became indicators of flawed moral characteristics such as selfishness, over-indulgence, and callousness (Bilton 2012: 54). Criticism against excessive fatness became widespread in America during the early twentieth century, and popular fat clubs began to collapse due to the increasingly negative public perceptions of fatness (Mikkelsen 2003: 111).

Shifts in societal discourses regarding fat and obese bodies are also observable in the national reception of obese presidents. Elected as president between 1885-1889 and 1893-1897, Grover "Uncle Jumbo" Cleveland was an admired authority figure who weighed 275lbs and had a BMI of 34.6 kg/m^2 (Bilton 2012: 55). While President Cleveland was received positively by the public, shifting American ideas on fatness resulted in the national ridicule of President Taft. Serving as president between 1909-1913, William Howard Taft was a severely obese man who weighed between 320-340lbs and had an estimated BMI of 45 kg/m^2 during his time in the White House (Eknoyan 2006: 424). President Taft was regularly depicted in political cartoons as weak and childish, and new pejorative terms such as "butterball", "porky", and "dumpy" were used to ridicule the president's physical appearance (Mikkelsen 2003: 111; Bilton 2012: 54). News reports mocked Taft when he became stuck in the White House bathtub, and he was also ridiculed for being too heavy to be carried on a rickshaw while visiting Japan (Bilton 2012: 55). Ridicule is often utilized as a disciplinary function in order to police bodies that deviate from societal norms, and excessive flesh is often seen as out of place according to western societal standards of body size (White 2013: 326; Forth and Leitch 2014: 12). Taft's excessive fatness hindered his mobility and prevented him from performing simple daily activities, and these incidents reinforced the idea that excessive fatness was an embarrassing physical trait that should be avoided (Vigarello 2013: 7).

Body fatness also became politicized during periods of national emergency. During World War I (1914-1918), President Woodrow Wilson was urged to increase food conservation efforts in order to feed American allies while simultaneously avoiding national food shortages (Mikkelsen 2003: 111; Bilton 2012: 54). President Wilson assigned Herbert Hoover as director of the United States Food Administration, and

Hoover established a voluntary program aimed at convincing Americans to ration their food intake in support of American troops (Bilton 2012: 54). Americans were taught that patriotism should be demonstrated through the consumption of smaller food portions that were low in meat and heavy in fruits and vegetables (Bilton 2012: 54). Consequently, fat bodies were perceived as greedy and anti-American while thinner bodies became statements of national loyalty (Cassell 1995: 425; Bilton 2012: 54).

Shifting American ideologies ascribed moral and political meanings onto fat bodies, and the medicalization of these bodies began when insurance companies established a relationship between fatness and personal health. The Metropolitan Life Insurance Company sought to assess the health of potential clients compiling observations that linked body weight and mortality; moreover, these observations were developed into charts that indicate the ideal and desirable weights for adults (Mikkelsen 2003: 111; Caballero 2007: 1; Nuttall 2015: 118; Komaroff 2016: 2; Schultz 2017: 246). These charts were the among the first to establish a relationship between increasing body weight and deteriorating health (Mikkelsen 2003: 111; McCullough and Hardin 2013: 2; Komaroff 2016: 2). Insurance companies began using these standards in order to increase their profits. Clients with an 'ideal' BMI would require less medical expenses and make more payments due to their increased longevity (Schultz 2017: 245). Because overweight and underweight BMIs were associated with deteriorating health, customers who were classified as unhealthy were either offered policies with increased premiums or denied for coverage altogether (Schultz 2017: 245).

Fat bodies became indications of impending death, which created a panic that impelled Americans to participate in in weight-loss programs in order to discipline their bodies according to societal normalcy and prevent weight gain (Mikkelsen 2003: 111; Puhl and Brownell 2003: 213; McCullough and Hardin 2013: 3). The weight-loss and diet industry thrived on the stigmatization of body fat, and these programs advertised the idea that weight management is dependent on personal volition alone (Freidman 2004:

564). Obesity is commonly referred to as a disorder of personal behavior (Caballero 2007: 4); however, the American Medical Association (AMA) voted to classify obesity as a disease in 2013 (Schultz 2017: 236-237). This classification was intended to redirect prevention strategies away from altering individual behavior; instead, physicians in the AMA argued that attention should be focused on changing the obesogenic environments that promote increasing obesity prevalence (Schultz 2017: 236-237). While fatness was initially perceived as an indicator of social and class status in early America, the medicalization of fat redirected societal attention towards the health consequences associated with excessive fatness.

These critical societal discourses have resulted in the discrimination of excessively fat bodies. It has become common for obese individuals to experience prejudice and discrimination in public and private social settings (Crandall 1994: 883; Cassell 1995: 424; Puhl and Brownell 2001: 788; Schultz 2017: 240). Discrimination against obese bodies is due to the highly visible properties of excess body fat, which provokes public surveillance and criticism of moral character based on physical appearance (Bray 1998: 161; McNaughton 2011: 181; Nuttall 2015: 117). Prejudiced perceptions of fat bodies stem from debates on the contribution of personal responsibility in the etiology of overweight and obesity (Bray 2015: 352). Research often refers to obesity as a preventable condition, which advances the assumption that body weight is within personal control (Ofei 2005: 98). Holding excessively fat individuals personally responsible for their physical condition fuels the unapologetic attitudes towards obese people in modernized societies (Crandall 1994: 892; Puhl and Brownell 2003: 215; Becker 2013: 37). This results in the marginalization of fat and obese individuals, who are now targeted as gluttonous and moral failures (Townend 2009: 179).

The history of obesity demonstrates the stigmatization of body fatness through the processes of moralization and medicalization. However, this history provides a mere glimpse into the stigmatization of fat bodies; additionally, it only focuses on fatness in contemporary western societies. This thesis argues that an archaeological analysis on prehistoric and ancient discourses will provide further insight on early societal idealizations of body size and fatness. Through the analysis of skeletal remains and visual representations, an archaeological study of obesity will attempt to identify the social values ascribed to fat bodies among prehistoric and ancient societies.

Thesis Chapters

The first four chapters of this thesis aim to define and elaborate on the concepts of fat and obesity. Chapter 1 presents an introduction to the subject matter while also discussing the methodology and literature utilized in this thesis. The methodology section justifies why critical discourse analysis is an appropriate method for this thesis, and the literature review provides a brief description of the major texts that influenced the development of this topic. Chapter 2 defines the concepts of fat and obesity; additionally, this chapter further elaborates on the stigmatization of fat through moralization and medicalization by including studies that exemplify the variation in cultural perceptions on body fatness. Chapter 3 examines the various evolutionary theories regarding the adaptive strategies of human adiposity, and chapter 4 analyzes theories regarding the possible causes for the emergence of obesity in modern humans.

Chapters 5-7 provide an analysis on the direct and indirect methods that are available for archaeological studies on obesity. Chapter 5 examines the advantages and limitations of body mass estimation, which is a direct method used in identifying obesity among skeletal human remains. Indirect methods are discussed in chapters 6 and 7. Chapter 6 focuses on identifying obesity in bioarchaeological remains through an investigation of associated skeletal pathologies. These pathologies include diffuse idiopathic skeletal hyperostosis (DISH), hyperostosis frontalis interna (HFI), and metabolic arthritis (gout). Chapter 7 focuses on studying obesity in prehistoric and ancient contexts by analyzing visual representations of fat and obese bodies. This includes analyzing material artifacts such as anthropomorphic figurines, ancient sculptures, and painted portraits. The indirect analysis of obesity will utilize case studies from a range of cultural and chronological contexts; moreover, cross-cultural studies will demonstrate the variation in societal discourses on fat bodies. The final chapter summarizes the archaeological presence of obesity in North American contexts, and this chapter concludes the thesis by discussing the advantages and limitations of archaeological obesity research while also noting the implications for future obesity research in North America.

Methodology

The purpose of this thesis is to strengthen knowledge on shifting obesity discourses through an archaeological analysis, and this goal will be accomplished by utilizing critical discourse analysis (CDA) methodology. CDA is an approach that examines how discourses present their versions of the social world (Daneski et al. 2010: 733). Wodak and Meyer's 2009 book chapter "Critical Discourse Analysis: History, Agenda, Theory, And Methodology" provides a detailed explanation of CDA. CDA is concerned with elucidating societal ideologies and authority through systematic and abductive inference of semiotic data (Wodak and Meyer 2009: 3). This includes analyzing the role that discourse plays in the construction of social dominance (Van Dijk 1993: 249). Academic literature generally prioritizes Western and European perspectives and disregards crucial issues of power, contingency, and agency (Warren 2012: 518). Dominant ideologies often appear neutral, and the assumptions within these ideologies remain largely unchallenged; however, CDA utilizes an interdisciplinary approach in order to understand how discourse aids in constructing complex social phenomena (Blommaert and Bulcaen 2000: 448; Wodak and Meyer 2009: 8). CDA is utilized by researchers in order to detect the social means used by privileged groups in order to stabilize or even intensify inequalities in society (Van Dijk 1993: 252; Blommaert and Bulcaen 2000: 447; Wodak and Meyer 2009: 33). CDA is appropriate for this thesis because it aims to clarify the discursive aspects of societal disparities and inequalities. CDA is also advantageous because it aids in analyzing how societal discourses reproduce dominant western ideologies that justify the marginalization of fat and obese bodies.

Data collection for CDA is dependent on the research question. Researchers utilizing CDA generally begin their study with a first-collection exercise, in which the researcher gathers broad sources in order to develop a preliminary analysis. The initial data collection and analysis will allow for the identification of specific concepts of interest which can be expanded into key research categories. Further data collection, also known as theoretical sampling, will then improve upon initial findings and create necessary modifications to the research questions being studied (Janks 1997: 331; Wodak and Meyer 2009: 28). This method is commonly used in social science studies due to the interaction between theory and empirical data (Wodak and Meyer 2009: 30). Moreover, this thesis will implement this aspect of CDA in order to connect the archaeological materials to the grand theories and concepts developed by academic obesity research.

CDA is strongly based in theory and places an emphasis on analyzing texts that are relative to the social problem being studied (Wodak and Meyer 2009: 23). The concentration on published literature is based on the non-reactive strengths of the data. The collection of sources usually includes texts that are not specifically produced for the respective research project (Wodak and Meyer 2009: 32). Because there exists a dearth of archaeological literature focusing on obesity in prehistoric and ancient contexts, the interdisciplinary aspects of CDA methodology will allow for a stronger development for the archaeology of obesity. Researchers who utilize CDA are cautioned to keep description and interpretation separated, which creates transparency through abductive reasoning regarding the respective study (Blommaert and Bulcaen 2000: 448; Wodak and Meyer 2009: 33). This thesis will also use CDA methods to identify instances in academic scholarship where researchers fail to separate their contemporary ideas from the data, which results in the generation of false assumptions and generalizations regarding obesity.

In order to understand how obesity is being referred to within public and academic discourses, definitions of important terms are required. This includes investigating the meaning and stigmatization of words such as "fat" and "obese". Differentiating between fatness and obesity is an important task for this thesis, as it will establish guidelines that can be used to identify relevant academic literature. Every study on fatness does not necessarily include a study of obesity. Research specializing on the topic of obesity will refer to the specific standardized measures used to diagnose obesity among global populations, such as BMI and waist-to-hip ratio. Therefore, this thesis identifies the terminology and measures that are appropriate in studying obesity among archaeological materials. The organization of this thesis is influenced by the emphasis that CDA places on the interaction between theoretical and empirical evidence. Each chapter will address major theories and concepts regarding obesity, and an analysis of relevant case studies of obesity in archaeology will follow. This sequence allows for a productive analysis of obesity within archaeological contexts.

Literature Review

Although research specializing in the archaeology of obesity is lacking, anthropological studies on obesity are more common in academic literature. The first scholar to advocate for an anthropological perspective on obesity was American anthropologist Hortense Powdermaker, who published a paper in 1960 proposing that obesity research should incorporate cultural analyses on the social values placed on fat and thin bodies (Powdermaker 1960: 286). Powdermaker presents a connection between obesity prevalence and modern environments, which leads her to question the possible relationships between body size and social class, ethnicity, spirituality, sexuality, and age (Powdermaker 1960: 286). Twenty-seven years after Powdermaker's publication, Brown and Konner published an anthropological study of obesity which elaborated on the topics previously posited by Powdermaker. Brown and Konner's text was influential in establishing three epidemiological facts regarding obesity, which stated that that 1) Sexual dimorphism in *Homo sapiens* is exhibited through increased female fat levels, 2) Obesity is rare in primitive societies but prevalent in modern societies, and 3) Obesity prevalence is reliant on social class (Brown and Konner 1987: 30). These three asserted facts provoked a surge of research studies attempting to support or refute Brown and Konner's theories.

Anthropological studies on obesity commonly focus on contemporary issues and neglect to incorporate an archaeological perspective. The topic for this thesis extends from Bellisari's 2016 book "The Anthropology of Obesity in the United States". Bellisari focuses on the biological, social, and environmental aspects of obesity and explains how these factors may contribute to the rising obesity rates in the United States. Other similar texts include Lieberman's 2013 book "The Story of the Human Body: Evolution, Health, and Disease" and Brewis' 2011 text "Obesity". These three books investigate the increasing prevalence of obesity in contemporary societies by identifying changes in human biology and culture. Bellisari's and Lieberman's texts specialize in the examination of obesity prevalence within contemporary United States, while Brewis' cross-cultural research focuses on obesity in the United States, Mexico, and Pacific Island regions. All three authors utilize biological and evolutionary research to explain the emergence of obesity among modern humans; however, all three authors fail to mention the possible archaeological manifestations of obesity. An analysis of archaeological representations of obesity will support evolutionary theories regarding the emergence of excess fatness while also providing insight on the variation in social values that prehistoric and ancient societies may have ascribed to fat.

This thesis aims to analyze the influence that shifting societal discourses have on the stigmatization of fat and obese bodies, and three texts that provide excellent research on the moralization of body fat include Hill's 2011 book "Eating to Excess", Gilman's 2008 book "Fat: A Cultural History of Obesity", and Vigarello's 2013 book "Metamorphoses of Fat: A History of Obesity". Hill asserts that negative perceptions on body fatness stem from historical and cultural factors, and her research specializes on the religious influence in associating excess fatness with morality and gluttony. Similarly, Gilman's research focuses on nineteenth century associations between gluttony, health, and fatness within Western and Chinese contexts. Gilman also elaborates on the development of societal anxieties its contribution in the stigmatization and discrimination of fat and obese bodies in contemporary contexts. Vigarello's research specializes in Western discourses on body fatness, and his analysis focuses on social discourses emerging as early as the Middle Ages. The research conducted by Hill, Gilman, and Vigarello clearly demonstrate how shifting social values affect societal perceptions on excess body fat.

The final two books that influenced the development of this thesis topic is Raisborough's 2016 book "Fat Bodies, Health, and the Media" and Yates-Doerr's 2015 book "The Weight of Obesity: Hunger and Global Health in Postwar Guatemala". Raisborough's research provides a thorough analysis of the influence that the mass media has on the portrayal of fat bodies; additionally, Raisborough identifies how fat stereotypes are constructed by moralized and medicalized societal discourses on obesity. In contrast, Yates-Doerr's ethnographic research on obesity in the community of Quetzaltenango, Guatemala demonstrates the conflicting discourses that exist between medical practitioners and the indigenous population regarding the concepts of fatness and health. While these two texts present an analysis on obesity discourse in differing contexts, the authors both elaborate on the major conceptual frameworks that are frequently used in studying obesity in anthropology including the processes of idealization, moralization, and medicalization. Moreover, this thesis attempts to apply these frameworks in the archaeological analysis of obesity.

Chapter 2: Terminology

Researchers often describe obesity as a disease of modernity that is initiated by a complex interaction of biological and environmental factors (Racette et al. 2003: 279; Apovian 2016: 178). It is widely believed that obesity is a modern phenomenon that emerged among industrialized Western societies during the late nineteenth century (Brown and Konner 1987: 35; Stolberg 2012: 370). However, further cultural and literary analysis indicates that the medicalization of obesity emerged much earlier in ancient and medieval contexts (Bradley 2011: 10; Stolberg 2012: 371). Medicalization is a term that refers to the process in which human concepts are defined and treated as medical problems (Batnitzky 2008: 456; Sadler et al. 2009: 412), and an analysis of early medicinal literature reveals that obesity began to be associated with diseases such as apoplexy, paralysis, asthma, and fevers (Stolberg 2012: 371). While obesity is discussed in early medical literature, scientific measures of obesity were only established in the early twentieth century. This chapter focuses on differentiating between the concepts of obesity and fatness. An integral portion of defining obesity requires a thorough understanding of fat as adipose tissue; therefore, the first section focuses on defining and explaining the biological functions of adipose tissue. The second section defines obesity and identifies the various measures used to diagnose obesity among global populations. The third section defines fat as a de-medicalized substance, which allows for a broader analysis on the emergence of possible positive connotations associated with fatness. Following this section is an analysis of fat stigma in modern societies, and the final section presents multiple examples of cultural perspectives on body fatness among contemporary populations. These studies will demonstrate how the construction of fatness varies between cultural groups.

Fat as Adipose Tissue

The identification of obesity relies on the standard measurement of human body fat, which is medically referred to as adipose tissue. Adipose tissue is a complex organ that serves as an inert storage layer that insulates the body and acts as a protective cushion for the inner organs (Frisch 2002: 5; Raisborough 2016: 9). White adipose tissue exists as two major deposits on the human body: subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT). SAT varies in thickness and gathers directly beneath the skin on the trunk, arms, and legs (Bellisari 2016: 12). VAT surrounds the internal abdominal organs and is determined to be more hazardous to human health when compared to SAT (Ofei 2005: 98; Bellisari 2016: 12). The severity of obesity related chronic diseases is dependent on body fat distribution rather than overall body mass, and excess VAT has been linked with increased risk for cardiovascular and metabolic diseases (Matsuzawa et al. 2011: 630-631). Adipose tissue is metabolically active, and body fat cells called adipocytes store fat as a potential source of energy (Frisch 2002: 5). Adipocytes also produce hormones and other signaling molecules that regulate hunger, energy balance, and body composition [see chapter 3] (Williams 2013: 8753; Bellisari 2016: 15).

The number and size of adipocyte cells determines the amount of energy that is stored within the human body, and obese individuals are estimated to have more than twice the amount of fat cells compared to normal BMI individuals (Bellisari 2016: 14). While adipose tissue is essential for bodily development and basic function, excess adipose tissue is associated with a surfeit of non-communicable chronic diseases such as diabetes mellitus type II, hypertension, cardiovascular diseases, and a variety of cancers (Racette et al. 2003: 276; Ulijaszek and Lofink 2006: 339; Muoio and Newgard 2014: 1). Scientists have found that adipocyte cells thrive in a specific microenvironment that also promotes tumor cell growth. The optimal microenvironments for adipocyte and tumor cell development are dense with blood vessels, local inflammation, and increased nutrient flow (Williams 2013: 8754). As a result, high levels of adiposity are often referred to as toxic due to the correlation between adipose tissue and poor health (Wells 2012: 595). The process of medicalization transforms adipose tissue into a measure of human health;

moreover, societal associations between obese bodies and chronic diseases has contributed to the idea that fat bodies are visual indicators of disease and mortality.

Measures of Obesity

Obesity is a medicalized concept that predominantly focuses on statistical criteria of human adiposity levels (Wells 2012: 595; McCullough and Hardin 2013: 5). Obesity is scientifically defined as an excess of adipose tissue that is equal to or exceeds a body mass index (BMI) of 30 kilograms/meters^2 (O'Rahilly and Farooqi 2006: 1097). BMI is calculated by dividing body weight in kilograms by the square of height in meters (Keys et al. 1972: 340; Quetelet 1994: 83; Gallagher et al. 1996: 228; Nicholls 2013: 9). Originally referred to as Quetelet's Index, BMI was founded in 1832 by statistician Lambert-Adolphe-Jacques Quetelet (1796-1874) who developed this index in order to define the 'average' man (Gallagher et al. 1996: 228; Peters et al. 2010: 1349; Nicholls 2013: 9; Nuttall 2015: 118; Schultz 2017: 246). In 1972, Keys and colleagues published a study that advocated BMI as the best indicator for fat mass that could be utilized in cross-population studies (Keys et al. 1972: 331; Schultz 2017: 246).

BMI categories include underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥ 30 kg/m^2) classifications (Tsai et al. 2010: 51). The BMI method is utilized to identify obesity among both adults and children. However, BMI in adults is determined by the set cut-point categories relating to health risks, while obesity in children is based on a comparison to a reference population due to their ongoing height development (Ogden et al. 2015: 6). BMI is the main proxy used for identifying obesity among modern humans due to its ease and cheapness. Individuals can calculate their own BMIs at home without the need for expensive equipment, and it is also convenient for researchers to measure adiposity using the same BMI standards across global populations (Keys et al. 1972: 330; Gallagher et al. 1996: 228; Racette et al. 2003: 276; Becker 2013: 29; Raisborough 2016: 56; Schultz 2017: 246).

While this simple method is predominantly used by global health communities, BMI is often criticized for oversimplifying body fatness. BMI does not directly measure body fatness (Racette et al. 2003: 277; Ogden et al. 2015: 6; Nuttall 2015: 120; Schultz 2017: 245); moreover, it fails to account for muscle mass and bone density (Toulalan 2013: 66; Raisborough 2016: 56). This is a problematic issue, as entire groups of people (such as elite athletes) are misclassified as obese due to exhibiting larger-than-average muscle masses or bone densities (Curtis 2004: 39; Becker 2013: 29). Additionally, BMI assumes that all subjects experience similar fatness without considering the influences of age, sex, or ethnicity (Gallagher et al. 1996: 228). Critics argue that BMI is a flawed indicator for health, as individuals may be able to produce healthy BMI readings despite having increased fat mass and decreased muscle mass (Racette et al. 2003: 277).

The sudden increase in American obesity rates are commonly attributed to changes in the definition of obesity. In 1998, the United States government issued new guidelines regarding BMI classifications. These guidelines lowered the BMI standard for the overweight category from 27 kg/m^2 to 25 kg/m^2, which simultaneously lowered the BMI standard for obesity (Brewis 2011: 11; Nuttall 2015: 119-120; Schultz 2017: 247). As a result, 29 million additional Americans were clinically classified as obese overnight due to the alterations in BMI classification (Brewis 2011: 11; Nuttall 2015: 119-120; Schultz 2017: 247). BMI is also imprecise due to the potential for human error. Approximately 20% of adults are classified in the incorrect BMI category due to the inaccuracies of self-reported height and weight (Janssen et al. 2004: 382).

Critics also argue that BMI is a flawed method in determining human health because it does not acknowledge the distribution of body fat (Yates-Doerr 2013: 52; Nuttall 2015: 121; Schultz 2017: 245). Based on the health implications regarding the presence of VAT, researchers argue that BMI methods should be abandoned for waist circumference (WC) measures. Researchers have indicated that health risks are associated with a WC greater than 35 inches among women and 40 inches among men

(Janssen et al. 2004: 380; Ofei 2005: 99). Obesity can also be determined through waist-to-hip ratios (WHR), where waist circumference is divided by hip circumference to determine body fat distribution. Abdominal obesity is diagnosed as a WHR of 0.90 in males and 0.85 in females (WHO 2008: 27). Critics of BMI argue that WC is a better predictor of morbidity than weight alone because it specifically targets the measurement of abdominal obesity (Racette et al. 2003: 277; Haslam and Wittert 2009: 18; Yates-Doerr 2013: 55); additionally, only 2% of adults are classified in an incorrect WC category due to inaccuracies of self-reported WC measurements (Janssen et al. 2004: 382). Prior to the establishment of BMI as the main proxy for obesity identification, waist circumference was also utilized to identify obesity in humans during seventeenth century Europe; however, these standards were stricter, as high health-risks for males were indicated by a waist circumference of 36 inches (Bradley 2011: 6).

Other researchers argue that bioelectrical impedance analysis (BIA) is the most accurate method for identifying obesity and measuring human health. BIA measures the resistance to low frequency electrical signals as they pass through adipose tissue, lean mass, and water within the body (Racette et al. 2003: 277; Haslam and Wittert 2009: 20; Yates-Doerr 2013: 57); as a result, BIA acknowledges bone density and muscle mass. While scientists may consider BIA to be a highly-precise method of identifying obesity and its related health risks, this is an inconvenient method for obesity researchers due to the expensive cost of owning a bioimpedance scale (Yates-Doerr 2013: 58). Standard weight scales for BMI and measuring tape for WC are much more accessible and cost-friendly for medical practitioners and the general public. As a result, the global health community favors the BMI method in assessing adiposity rates across worldwide populations.

Moralization and Medicalization of Fat

Fat and obesity are similar yet distinct concepts. The definition for obesity refers to the scientific measure of fat as adipose tissue within the body. Researchers have argued that the measurement of adipose tissue for the diagnosis of obesity stigmatizes fatness as a source of illness and disease (Raisborough 2016: 58). Consequently, defining fat as adipose tissue creates a clinical discourse that may not be present in discourses of the ancient world (Hill 2011: 3). Therefore, it is important to analyze fat as a de-medicalized substance in order to better understand archaeological discourses regarding fat bodies. De-medicalization is a process in which corporeal conditions lose their status as medical entities (Sadler et al. 2009: 411). Removing clinical associations attributed to fat will allow for a broader study of fat among populations where medicalized associations are inapplicable. An analysis of the evolution of the meanings of fat will demonstrate how shifting social values influence societal perceptions of fat and obese bodies.

A de-medicalized definition for fat refers to a material substance that exists internally and externally of the human body (Forth 2014: 42; Raisborough 2016: 27). This definition does not adhere to specific metric standards, and this allows for a broader analysis of fat in archaeological contexts. External fat substances refer to the solid and liquid states of animal and plant fats. The unctuous quality of external fats allowed it to be burned to produce fire and light, and animal fats were often burned in Palaeolithic stone lamps in order to allow humans to remain active throughout the night (De Beaune 1987: 570; Forth 2014: 44). The ancient Greek philosopher Aristotle (384-322 BCE) metaphorically referred to human life as a lamp that slowly consumed its oil (Forth 2014: 45). These early ideas on the material substances of fat developed positive connotations that allude to light and life. The symbolism of fat as life is also observed in Marcus Terentius Varro's (116-27 BCE) descriptions agricultural soil. Varro wrote that agricultural soil must be "fat" or unctuous in nature in order to successfully produce food resources (Forth 2014: 45; Varro 1918: 90). While positively referring to fat as necessary for agricultural success, this description also carries negative connotations as the substances that help make soil productive and "fat" will typically consist of rotten matter that elicits a reaction of disgust from humans (Forth 2014: 46). The properties of "fat" soil associates the term with both negative and positive connotations, which demonstrates the oppositional discourses that existed regarding fat. Fat as an internal bodily substance also became a metaphor for life. Body fat covers the bony edges of the human skeleton, which Western societies perceive as symbolic of death. Moreover, increased levels of body fatness reduce the visibility of the skeleton and symbolizes the erasure of death (Forth 2014: 48). The relationship between fat and life also explains the stigmatization of emaciated bodies, as thin bony bodies were commonly associated with malnutrition and death (Bilton 2012: 55).

Social categories that are present within a society will influence the physical experience of the body (Douglas 2002: 69). Stigmatization of body size results from the interconnected processes of moralization and medicalization, and these stigmas are used to establish social groups within societies (Puhl and Brownell 2003: 215). The process of moralization establishes an association between a physical illness and moral failings (Townend 2009: 178), and historical analyses indicate that pre-industrial Western societies commonly explained the emergence of diseases as the result of immoral character (Daneski et al. 2010: 731). Nineteenth century colonial scholars negatively perceived excess fatness as indications of gluttony and primitiveness, whereas thin bodies were idealized representations of self-discipline and civilized society (Pollock 1995: 357; Gilman 2008: 80; Forth 2012: 235). These moralized Western ideals were used to justify the marginalization of bodies that did not conform to societal standards, and fat individuals were pressured into losing weight in order to become socially accepted. The social pressures influencing body management is indicative of the control held by societal discourses in regulating members of Western societies (Douglas 2002: 74).

The medicalization of fat is the product of associating body fatness with morality and health. The term "health" is used as a metaphor for self-control, and excessive fatness is commonly associated with lack of self-discipline (McNaughton 2011: 181; Brewis et al. 2011: 269). However, early nineteenth century discourses regarding the life and death of Daniel Lambert (1770-1809) provide a unique distinction between the concepts of fatness and health. Lambert was an Englishman from Leicester who was thirty-nine years old and weighed approximately 739lbs at the time of his death in 1809 (Gilman 2008: 84; Haslam 2014: 57). Although severely obese, society perceived Lambert as healthy and did not attribute his death to his excessive fatness (Gilman 2008: 85). Another distinction between health and fatness is described in William Banting's 1863 "Letter on Corpulence Addressed to the Public", in which he writes how he transitioned from corpulence to obesity (Banting 1993: 154; Gilman 2008: 80). Banting defines obesity as a parasite to humanity, and he describes how his obesity produced new painful bodily ailments and lowered his quality of life (Banting 1993: 155; Gilman 2008: 84). The intense pain associated with Banting's obesity provoked him into losing weight by restricting his intake of carbohydrates (Banting 1993: 154). After losing 35lbs, Banting associated his new thinner body with a happy and comfortable existence (Banting 1993: 154; Gilman 2008: 82-83). Banting's letter connects poor health with obesity but not with corpulence, and these observations are based on his experiences with the painful bodily ailments that accompanied an obese body.

Fat Stigma in Modern Society

The medicalization of fat bodies has resulted in prejudiced discourses that perpetuate contemporary mass media. Television programs promote medicalized discourses that reflect a morbid fascination and reproach for obesity (Haslam and Rigby 2010: 86). Shows such as The Biggest Loser, Obese: A Year to Save My Life, and My 600-lb Life emphasize the relationship between excess fat and deteriorating health, and weight loss is presented as a moral resolution to obesity (Raisborough 2016: 77). The critical discourses surrounding obesity do not only describe social ideals regarding body fatness; instead, these discourses actively produce societal values by devaluing fat bodies and presenting them as medically and morally wrong (Murray 2007: 362). These values also affect the representation of fat bodies in popular television programs. An analysis of popular television programs indicates that fat characters are more likely to be targets of ridicule and humiliation compared to their thin counterparts (Puhl and Brownell 2003: 214; Greenberg et al. 2003: 1347). Overweight characters are underrepresented and attributed with flawed personality traits, whereas thin characters are overrepresented and embody positive characteristics (Puhl and Brownell 2003: 214; Greenberg et al. 2003: 1343). The lack of representation coupled with fat stereotypes in mass media may result in self-fulfilling prophecies, in which obese individuals conform to these stereotypes because they are presented as universal truths (Puhl and Brownell 2003: 214).

The word fat is a pejorative term used to describe either an overweight person or processed foods that are detrimental to human health (Muoio and Newgard 2014: 1; Brewis et al. 2011: 269). Fat has also become closely associated with gender, race, and class prejudices. Morton analyzed the strength of these associations by studying their search frequencies on Google.com. Fat is a controversial term in contemporary societies, and negative perceptions of fat has resulted in the emergence of euphemistic expressions that are used to avoid offending fat bodies (Longhurst 2005: 249; Xiaoling et al. 2012: 67). Morton included an analysis of euphemistic terms such as "plump" and "portly" in order to juxtapose these connotations with those of "fat". The term "plump" is commonly associated with femininity, and this is supported by the associations Morton observed on Google. The phrase "plump woman" appeared approximately 6x more than "plump man" (91,100 versus 15,500 results) (Morton 2007: 6). In contrast, the term "portly man" appeared approximately 52x more than "portly woman" (39,200 versus 746 results) (Morton 2007: 6). Google search results also revealed an association between "portly" and class status, as the term was frequently used as a descriptor for high-class occupations such as doctors and lawyers rather than middle- and low-class occupations such as teacher and plumber (Morton 2007: 6). An inverse relationship was observed when analyzing the term "fat". "Fat teacher" appeared approximately 9x more than "fat professor" (10,600 versus 1,190 results), which indicates an association with low-class occupations (Morton 2007: 6). Racial associations were also evident, as "fat white man" appeared 12x more than "fat black man" (9,190 versus 773 results) (Morton 2007: 6). The phrase "fat black woman" appeared approximately 7x more than "fat white woman" (75,550 versus 10,400) and 8x more than "fat white man" (Morton 2007: 6). Gender prejudices in fat terminology are not new phenomenon, as Morton notes that the Oxford English dictionary includes numerous pejorative terms aimed towards women and not men such as fussock, fustilugs, and sow (Morton 2007: 6). This study demonstrates the differences in modern societal ideas regarding fat bodies of various gender, race, and class.

Cultural Perceptions on Fat

Cultural ethnographies can provide further insight on the variation in social discourses regarding fat and obese bodies in contemporary, non-western populations. Perceptions on ideal body size varies with culture, ethnicity, educational level, and socioeconomic status (Holdsworth et al. 2004: 1562). Moreover, the idealization of a specific body type is largely influenced by cultural and environmental factors (Rguibi and Belahsen 2006: 620). Cultural ideas and behaviors are diverse within and between contexts; therefore, each cultural setting requires an in-depth investigation (Hruschka and Hadley 2008: 948). Cross-cultural analyses will benefit obesity research by demonstrating that dominant societal ideologies regarding body size and image are not universal but are rather the result of normalization (Schultz 2017: 241-242). While cultural studies on obesity may provide beneficial knowledge of the construction of obesity in non-western societies, it is not without limitations. Translation errors can produce different meanings of the concepts of fat and obesity between cultural groups, and measurements of obesity may vary across cultures (Hruschka and Hadley 2008: 949). However, sociocultural analyses of body fatness identify the various ways in which social values affect the stigmatization of body fatness in non-western communities. The following sections provide examples on the varying perspectives among the populations in Morocco, Bolivia, Guatemala, Tahiti and Nauru.

Laayoune, Morocco

Obesity has significantly increased in Moroccan populations during the past few decades, and women are the most affected by obesity prevalence (Rguibi and Belahsen 2006: 620; Batnitzky 2008: 445). In 1984, 6.4% of women and 1.6% of men were clinically obese, and these rates rose to 22% of women and 8% of men affected in 2000 (Batnitzky 2008: 445). Rguibi and Belahsen analyze the body preferences of Moroccan women by conducting surveys and interviews of Saharawi women. The authors surveyed and interviewed 249 urban, non-pregnant women between the ages of 15-70 from the city of Laayoune in Morocco (Rguibi and Belahsen 2006: 620). The authors recorded data on the participants' BMI, sociodemographic status, body size satisfaction, dietary history, and behaviors regarding intentional weight gain or loss (Rguibi and Belahsen 2006: 620). Only Saharawi women characterized by their Hassaniyya dialect were eligible to participate. Rguibi and Belahsen focused their study on Saharawi women in order to analyze the effects that an altered environment and lifestyle has on body size preferences; moreover, the Saharawi are traditionally a nomadic population but increasing urbanization has been observed to influence traditional lifestyles and body weight (Rguibi and Belahsen 2006: 620).

The population for this study had a mean BMI of 28.6, and 79% of the participants were either overweight or obese (Rguibi and Belahsen 2006: 621). The majority of women desired to gain weight rather than lose it, and 87% of participants desired to gain weight at one point in life (Rguibi and Belahsen 2006: 621). Approximately 67% of women claimed to have used fattening practices to gain weight in the past, and 14% of participants were still using these practices at the time they were surveyed (Rguibi and Belahsen 2006: 621). Saharawi fattening practices are common prior to marriage, and women will undergo a process referred to as *tablah* that requires 40 days of intentional overeating with an extreme reduction of physical activity (Rguibi and Belahsen 2006: 622). Foods associated with *tablah* have also changed due to urbanization and the nutrition transition. A nutrition transition indicates shifts from traditional diets to diets high in sugar and refined grains (Batnitzky 2008: 446), and dietary and lifestyle changes resulting from rapid urbanization is through to promote obesity prevalence. Older Saharawi women use large quantities of camel milk in their cooking, while urban Saharawi women use olive oil, sugared milk, barley, rice, and camel fat and meat (Rguibi and Belahsen 2006: 622). Seeds such as *halba* (fenugreek) are also used as hunger stimulants and mixed into cooking (Rguibi and Belahsen 2006: 622). Excess body fatness is also associated with Saharawi identity. Saharawi culture requires women to dress in traditional clothes after puberty, and women believe that the traditional clothes require a heavier body to be worn properly (Rguibi and Belahsen 2006: 623). Dominant societal ideas regarding desirable physical traits may influence cultural practices. As demonstrated by Rguibi and Belahsen's study on Saharawi women, individuals may engage in specific daily routines to obtain and maintain the idealized body.

An analysis of gender roles and social class provides further insight on the prevalence of obesity among Moroccan women. Moroccan women gain gender specific roles once married, and these marital roles confine women to their households as they become the primary caretakers of the house and family (Batnitzky 2008: 453-454). Moroccan women also gain social status through aging, and household roles are passed on to younger women who join the household (Batnitzky 2008: 455). Aging women become sedentary and are encouraged to live a relaxed lifestyle after fulfilling her duties as a wife, mother, and mother-in-law (Batnitzky 2008: 455). Sedentism is also associated with high socioeconomic status, where women are less physically active because they are not pressured to leave the household and work out of economic necessity (Batnitzky 2008: 456). These sedentary lifestyles contribute to the increase of body weights among Moroccan women. Aging Moroccan women experience a decrease of physical activity while either maintaining or increasing her dietary intake, whereas aging Moroccan males maintain social roles outside of the household and remain physically active (Batnitzky

2008: 456). This study demonstrates how gender-specific increases in obesity are influenced by cultural social values and traditional gender roles.

Pocobaya, Bolivia

An ethnographic study illustrating the connection between fat and indigenous identity is Canessa's analysis of *kharisiris* among rural Andean populations (Canessa 2000: 706). This study focuses on the small Aymara-speaking village of Pocobaya, which is situated in the Bolivian Andes (Canessa 2000: 705). Pocobayeños are vocal about their fears of *kharisiris*, which refers to people who steal fat from the bodies of the indigenous people. The term *kharisiri* is used among Aymara speakers in south eastern Peru and Bolivia, and translates into English as slaughterer (Canessa 2000: 716; Blaisdell and Ødegaard 2014: 52). Quechuan speakers in Central Peru refer to *kharisiris* using the terms *(ene)nakaq* or *pishtaco* (Canessa 2000: 716; Blaisdell and Ødegaard 2014: 52). Ethnographic analysis of *kharisiris* among rural Andean populations allows researchers to identify the significance of fatness as symbols of identity and agency.

Body fat (*lik'i*) is central in Pocobayeño beliefs and is usually interpreted by researchers as a life force (Canessa 2000: 706; Blaisdell and Ødegaard 2014: 52). Pocobayeños view fatness as an advantageous physical trait that protects against hard labor and rapidly changing air temperatures, which is characteristic of life in the Andes (Blaisdell and Ødergaard 2014: 52). Pocobayeños that were asked how to stay healthy in these stressful environmental conditions replied with "I eat alot" (Blaisdell and Ødergaard 2014: 52). The importance of fat in Pocobaya is generally overlooked by researchers, as Western scholars are more preoccupied with the concept of blood (Canessa 2000: 709). Blood is a familiar concept in European culture and linked with spirituality and life; however, blood is never used as an offering in Pocobaya (Canessa 2000: 713). Fat accounts for human agency much more than blood does in Pocobayeño culture, and candles made from fat are often used in offerings to ancestral spirits (Canessa 2000: 710). Blood is an obscured substance that rarely makes an appearance in the daily lives of Pocobayeños, whereas body fatness is clearly visible to others and communicates information on the health of a person (Canessa 2000: 709-710). The social value placed on fatness may originate from exposure to malnutrition, which is a common condition found among rural Andean communities (Canessa 2000: 710).

The significance of fatness is demonstrated by the Pocobayeños' fear of *kharisiris*. *Kharisiris* are fat-stealers that are commonly associated with hacienda-owners, priests, and non-Indians (Canessa 2000: 213). The practice of fat stealing originates from the colonial period where Spanish soldiers used fat from the slaughtered bodies of Indians in order to salve their wounds after battle (Canessa 2000: 706). The identities of *kharisiris* evolve to reflect groups that Pocobayeños perceive as their oppressors. Up until the mid-twentieth century, *kharisiris* were identified as Franciscan monks who gave stolen fat to bishops to produce holy oils (Blaisdell and Ødergaard 2014: 52; Canessa 2000: 706). Fat was a major commodity among religious authorities, as priests were thought to derive their holy powers not from God but rather from the fat used in ceremonies (Canessa 2000: 710). The image of *kharisiris* shifted during the late-twentieth century, and Pocobayeños began to refer to North Americans as the new *kharisiris*.

While North Americans contacted Pocobayeños in an attempt to provide foreign aid, the villagers perceived these actions as attempts to oppress their indigenous lifestyles (Blaisdell and Ødergaard 2014: 52). Pocobayeños believe that American foreigners were stealing body fat and selling it to corporate manufacturers, and the fat was used to oil the machines thus increasing production efficiency and resulting in immense profit at the expense of indigenous people (Blaisdell and Ødergaard 2012: 52). The loss of fat at the hand of foreigners is symbolic of the social and political inequalities experienced by the indigenous populations in the rural Andes, and stories of *kharisiri* attacks are expressions describing the abuse and exploitation experienced by the indigenous Andean communities (Canessa 2000: 716).

Quetzaltenango, Guatemala

While some cultural groups perceive fat bodies as indicators of identity and class positions, others may connect fatness with emotional, spiritual, and moral states (Longhurst 2005: 250). Yates-Doerr's ethnographic research focuses on body image and identity among the indigenous Guatemalan populations in the city of Quetzaltenango, which is also referred to by the Mayan name *Xela*. Yates-Doerr explains how fatness may refer to an emotional state of happiness; alternatively, it could also refer to desirable aesthetics and beauty (Yates-Doerr 2013: 62). Phrases such as "*Donde no hay gordura, no hay hermosura*/Where there is no fat, there is no beauty" and "*Tan bonito el gordito*/What a beautiful little fattie" demonstrate the positive connotations ascribed to fatness by the indigenous communities in Quetzaltenango (Yates-Doerr 2013: 62). Another complimentary phrase is referring to children as "*gordito*/little fat one", which is a positive descriptor that focuses on the child's hearty appetite (Yates-Doerr 2015: 86). The association between fatness and health is also demonstrated through the phrase "*Ser gordo es ser sano*/to be fat is to be healthy (in the countryside)" (Yates-Doerr 2013: 62).

While Quetzaltecos may describe a link between fat and health, indigenous ideas conflict with medical discourses on body fat. Confusion is common when physicians attempt to explain that *masa*, a term that refers to both body fat and soft dough created from corn, should be restricted and controlled in order to prevent illnesses and promote good health (Yates-Doerr 2015: 5). Yates-Doerr recorded the confusion of a woman at an obesity clinic who stated that she should not be required to meet with a nutritionist because she is already "plump" enough (Yates-Doerr 2012: 293). The physicians' medicalized ideas on *masa* conflict with the Mayan K'iche story of creation, which states that humans were created from corn *masa*, thus linking *masa* with ideas on life (Yates-Doerr 2015: 5). *Masa* in contemporary Guatemala serves as an example of the oppositional discourses that surround fatness, as masa is both symbolic of life and death.

Oppositional discourses are evident in medical discourses that link corpulence with illness and moral failures such as gluttony and laziness (Yates-Doerr 2015: 86). Yates-Doerr noted that medical practitioners would also frame weight-loss in moral terms in order to encourage obese individuals into losing weight for their families (Yates-Doerr 2015: 108). Fatness is linked to gluttony among university-educated Quetzaltecos, and an obese body served as an indicator that the refusal to share food resources with their families (Yates-Doerr 2015: 122). Morality is also present in medicalized discourses of fat, and Yates-Doerr mentions health initiatives linking weight-loss with nationalism. Yates-Doerr describes a promotion for weight-loss and exercise using the motto "Healthy for life, Healthy for Guatemala". This promotion advocates for consciousness of the self with the intent of being the best for Guatemala. Weight-loss serves as a method for Guatemalans to secure their status as citizens by requiring less of the government and reducing public health costs through voluntary dieting and exercising (Yates-Doerr 2015: 96-97).

Tahiti and Nauru

Obesity rates are rapidly increasing among Pacific island populations, and prevalence has reach as high as 75% among the populations of Nauru, Samoa, American Samoa, Cook Islands, Tonga, and French Polynesia (Curtis 2004: 38; Haslam and Wittert 2009: 7). These islands have either been colonized or protected since WWII by United States, Australia, New Zealand, France, or the United Kingdom (Curtis 2004: 37). It is hypothesized that the rapid environmental changes resulting from colonial contact influenced the rising obesity rates among these island populations. While Western societies gradually acclimated to technological advances throughout the twentieth century, Pacific island populations were forced to adjust to these changes within a few decades (Curtis 2004: 38; Becker 2013: 30). The transition from a traditional to sedentary lifestyle may have promoted the rise in obesity rates among Pacific Islanders, as obesity prevalence among these populations is correlated with the introduction of processed foods, motorized transport, and urban migration (Zimmet and Whitehouse 1981: 204; Curtis 2004: 39; Becker 2013: 30).

However, fat bodies are not new to Pacific island populations. Fattening rituals predate modernization and were developed in accordance to local cultural social values (Pollock 1995: 358). Nineteenth century visitors such as English missionary William Ellis (1794-1872) and Belgian-French merchant Jacques-Antoine Moerenhout (1796-1879) observed the Tahitian practice of *ha'pori*, which means to make fat (Pollock 1995: 357; Craig 2011: 81, 165). Tahitians selected pubertal males and females from high ranking families to participate in fattening practices, and researchers believe that these practices served to enhance sexual attractiveness (Oliver 1989: 681; Pollock 1995: 357-358). Fattening practices occurred in seclusion and functioned to fatten the body while also lightening the skin by avoiding sunlight (Oliver 1989: 681). Following the seclusion period, the young *huipipi* (fattened ones) are were oiled, decorated, and presented to the local chief and public audience (Oliver 1989: 681).

Fattening practices are also present in Nauruan culture, where fatness is associated with beauty and fertility. Nineteenth century European visitors to Nauru describe the islanders as plump, and one woman was estimated to weigh around 400lbs (Pollock 1995: 358). The subjects for fattening practices are usually young Nauruan women from *temonibe* (chiefly) class (Pollock 1995: 91). Fattening practices would follow the celebration of the first menses, and young women were secluded for up to six months and supplied with an abundance of food by relatives (Pollock 1995: 91). Researchers speculate that women participated in these fattening rituals in an attempt to promote survival and fertility. Women who were unable to conceive were socially rejected, and fattening practices was thought to remedy infertility by increasing fat reserves that would aid in conception and pregnancy (Pollock 1995: 94). Fat bodies were also perceived as indicators of survival, as the extra fat reserves would provide enough energy for the mother and fetus during periods of food scarcity (Pollock 1995: 94). The emphasis of fatness in Nauruan culture has also impacted female identity, as women are given names such as *babu* (round), *etibat* (she is fat), and *ebabou* (obese one) (Pollock 1995: 93).

While both Tahitian and Nauruan populations engage in fattening rituals, these practices emerged independently from each other. Pacific islands are generally isolated areas that are prone to violent climates that can severely affect food resources (Gosling et al. 2015: 473). While Tahiti and Nauru are both located in the Pacific, the islands' vulnerability to famine differ from each other due to the significant variation in island ecologies (Gosling et al. 2015: 474). The island of Tahiti produces a variety of food resources that is rarely affected by droughts and climate damage (Pollock 1995: 359). However, the island of Nauru has limited food resources and is prone to extensive droughts that last up to three years at a time (Pollock 1995: 358-359; Diamond 2003: 600). The prosperous environment of Tahiti supports ideas linking *ha'pori* practices with aesthetic enhancement, while the unstable environment of Nauru reaffirms theories linking female fattening with fertility. Comparing the social values ascribed to fat bodies in Tahitian and Nauruan populations illustrates how societal perceptions of fat are developed by environmental, social, and biological factors.

Summary

It is common for social groups to ascribe cultural meanings to body size and fatness, which results in the construction of identities that reflect the broader social order (Brewis et al. 2011: 269). While fat as adipose tissue is hypothesized to be essential to the human body and allocated based on biological sex [see chapter 3] (Toulalan 2013: 69), the moralization of fatness fuels the unapologetic attitudes and prejudices that exists towards fat bodies in the U.S. (Becker 2013: 37). While the definitions of obesity and fatness demonstrate the various connotations and critical discourses associated with these terms, the theoretical reasons behind the emergence of excess body fat and obesity in humans is still undiscussed. Why was fatness selected as a beneficial evolutionary trait, and how did this influence the emergence of obesity? These are questions that are still highly debated among contemporary obesity researchers; moreover, the following chapter will provide an analysis on the origins of human adiposity and how it established a foundation for the presence of obesity.

Chapter 3: Evolutionary Perspectives on Human Adiposity

Researchers have attempted to explain the prevalence of obesity among contemporary global populations through an evolutionary analysis of the selection for human adiposity. Adipose tissue is a soft biological substance that does not preserve in the fossil record (Lieberman 2013: 132); therefore, academics attempt to analyze the selection for human adiposity through an evolutionary perspective. Understanding the selection for large adipose deposits on the human body will require a deeper look into the functions of fat among early humans. This chapter begins with a brief description of evolutionary game theory, which explains the utilization of adaptive strategies in order to meet basic biological functions. The next section analyzes the specific adaptive qualities of the selection for adipose tissue; additionally, this section also describes the variation in adipose tissue allocation between sexes. The last four sections elaborate on the theories regarding the purpose for the selection of fat deposits among humans. These theories focus specifically on the roles of fat in the processes of brain development, reproduction, immune function, and as a buffer against ecological stresses.

Evolutionary Game Theory (EGT)

An analytical model available to obesity researchers is Evolutionary Game Theory (EGT). Based on the classic mathematical paradigm of Game Theory, EGT has been used to understand how selective pressures affected the adaptive strategies of humans in response to potential conflicts of survival throughout human evolutionary history (Adami et al. 2016: 1). The rapidly changing environments surrounding archaic humans exposed them to selective pressures which required them to increase their physiological fitness through adaptive strategies (McHenry 1994: 77; Potts 1998: 104; Brewis 2011: 35). Within the context of obesity research, the application of EGT will provide further information regarding the selection favoring energy storage in the form of large adipose fat deposits on the human body.

A major component of EGT is the analysis of the set of strategies that increases fitness; additionally, EGT also provides an analysis of potential outcome differences between strategies (Adami et al. 2016: 23). EGT focuses on the phenotypes that will be successful in competition within an evolving population (Smith 1980: 73). This analytical model benefits obesity research by analyzing the evolutionary decisions regarding the usage and storage of energy entering the human body (Wells 2010: 210). EGT also considers how the numerous biological functions of the human body must compete for incoming energy, and this competition for energy determines how energy deposits will be allocated throughout the human body. Consequently, analyzing human adiposity through an evolutionary perspective establishes the premise that weight gain and corporeal fat storage is an essential human process that impacted the physiological fitness of early humans (Lieberman 2013: 269).

Adaptive Strategies of Fat

The emergence of body fat as adipose tissue is best described as a strategy of fitness (Lieberman 2013: 271). Evolution required the human body to efficiently use and store energy in order to ensure survival. Humans use energy to accomplish three basic functions: development, maintenance, and reproduction (Aiello and Wells 2002: 323; Lieberman 2013: 252; Bellisari 2016: 50). Ecological stresses such as migration, breeding, and hibernation temporarily overload the body with energy demands, and researchers hypothesize that the body favors fat storage as adipose deposits for future energy use (Kuzawa 1998: 179; Wells 2012: 599). Large fat deposits were likely selected due to its efficiency in storing energy, as a single gram of fat stores approximately nine calories (Aiello and Wells 2002: 329; Lieberman 2013: 131). The production of body fat results from an imbalance between the quantity of energy consumed (dietary intake) and the amount expended (total daily energy expenditure) (Racette et al. 2003: 280; Klok et al. 2006: 21; Wells 2010: 173; Colls and Evans 2014: 737). Fat molecules can be obtained by digesting caloric and fat-rich foods; additionally, the body can also synthesize fat through the consumption of carbohydrates (Lieberman 2013: 131). Because the production of fat requires a positive balance of energy intake, humans will require an increase of appetite that promotes an increase of energy consumption that surpasses energy expenditure [see chapter 4] (Wells 2010: 164). This energy imbalance results in the storage of energy as fat reserves on the body for future use.

The demanding energetic processes of the basic biological functions of the human body require an adaptive strategy that ensures constant access to energy. Moreover, evolution of the human body favored the strategy of storing lipids in fuel deposits rather than immediately oxidizing them for short-term fuel (Wells 2010: 9). When humans create a positive energy balance through the consumption of food, the incoming adipocytes are transferred via the bloodstream to various locations on the human body to be stored as adipose deposits (Lieberman 2013: 271). Various organs secrete hormones that stimulate the release of the energetic components of fat deposits in a process known as lipolysis (Lieberman 2013: 131; Bellisari 2016: 90). Fat loss occurs when physical activity, elevated energy metabolism, or reduced energy intake creates a negative energy balance and forces the body to draw energy from adipose deposits (Wells 2010: 158; Bellisari 2016: 90).

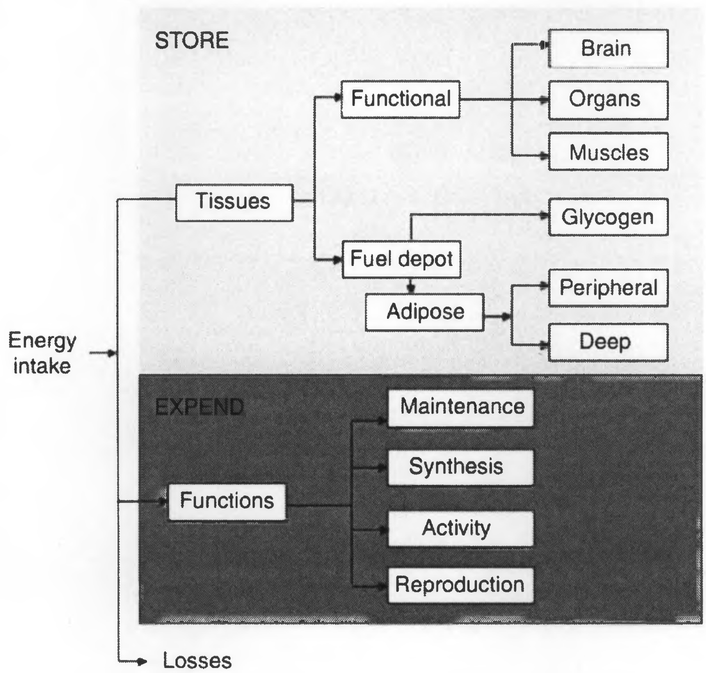


Figure 3.1. Competing biological functions for energy allocation (Wells 2010: 211)
Note: peripheral refers to subcutaneous fat; deep refers to visceral fat

These energy stores also regulate a set of competing biological functions, as illustrated in Figure 3.1. The metabolic system determines how incoming energy will be allocated, whether it is stored as proteins in organs and muscle tissues or as lipid in adipose tissue depots (Wells 2010: 210; Bellisari 2016: 96). Organ tissues are metabolically costlier than muscle tissue and require a stable source of energy (Wells 2010: 181). The presence of adipose deposits is crucial in that they provide a source of energy for these basic biological functions. The inability to supply the body with energy from fat stores will result in deterioration of lean muscle mass to produce energy. Subcutaneous fat is observed to be more sensitive to conditions of energy imbalance, whereas visceral fat is prioritized as an essential fat that functions as a protective cushion around vital organs (Wells 2010: 159; Brewis 2011: 38). Therefore, energy is generally drawn from subcutaneous fat rather than visceral fat.

The allocation of adipose tissue varies depending on factors such as age and sex (Wells 2010: 213). Sexual dimorphism is expressed through contrasting body fat levels between male and female *Homo sapiens* (Brown and Konner 1987: 30; WHO 2008: 8; Brown et al. 2010: 78). Sexually dimorphic fat patterns emerge during puberty, and evolution favored larger fat deposits on the female body (Singh and Singh 2011: 725; Bellisari 2016: 49). Female fat stores are referred to as gynoid or gynecoid deposits, while male stores are referred to as android deposits (Nuttall 2015: 121); additionally, these deposits are generally measured through waist-to-hip ratios (WHR) (Singh and Singh 2011: 725). Prior to puberty, males and females have similar fat distribution and WHR (Singh and Singh 2011: 725; Nuttall 2015: 121). Pubescent males tend to accrue lean mass rather than fat mass, and any fat mass is stored as large energy depots on the body (Wells 2010: 211; Nuttall 2015: 121; Bellisari 2016: 49). Female bodies accrue larger adipose deposits compared to male bodies, and women generally gain 5-10% more body fat than men (Lieberman 2013: 276; Bellisari 2016: 57). Pubescent females experience increasing estrogen levels that suppress fat oxidation, which results in the accumulation of fat as subcutaneous adipose depots on the femoral, gluteal, and mammary areas (Wells 2010: 211; Bellisari 2016: 49).

The allocation of fat is often regarded as a strategy to raise reproductive success. Fat allocation is also affected by life-course, where aging females and males will experience shifts in adaptive strategies to prioritize survival rather than reproduction. Menopause results in increased adiposity and shifts of body fat distribution, which increases risk for developing obesity, diabetes mellitus type II, and metabolic syndrome (Brown et al. 2010: 78, 83). Moreover, female body fat storage shifts from subcutaneous to visceral deposits, and both males and females will experience a reduction in muscle mass (Wells 2010: 211). Similarly, female WHR approaches masculine levels due to the reduction of estrogen levels (Singh and Singh 2011: 725; Nuttall 2015: 122). This tradeoff of reproduction for survival among aging humans is an example of EGT, where the competing biological functions at different life-stages will result in tradeoffs regarding allocation of body fatness (Wells 2010: 213; Adami et al. 2016: 1). Theories regarding the evolutionary selection for sexually dimorphic fat deposits in humans focus on the influences that brain development, reproductivity, immune function, and ecological stresses have on the human body.

Encephalization and Brain Development

Large brains are prohibitive and energy consuming for most species, and the encephalization of the brain amplifies the energy demands of the evolving *Homo* genus (Kuzawa 1998: 180; Lieberman 2013: 119; Kirchengast 2017: 40). Modern humans require five times more energy compared to mammals of equivalent body mass, and the human body dedicates one-quarter of basal metabolic energy to brain function (Bellisari 2016: 58). It is theorized that rapid brain evolution occurred with the emergence of *Homo erectus* approximately 1.6-1.8 million years ago, and the process of increasing brain size in referred to as encephalization (Ulijaszek and Lofink 2006: 341). Scholars assert that larger brains allowed humans to increase foraging efficiency and maximize returns while minimizing their physical effort (Ulijaszek 2006: 183; Bellisari 2016: 57). The increase in brain size may have been enabled by an increase of body fatness and diet quality (Ulijaszek and Lofink 2006: 341; Lieberman 2013: 132).

During the Miocene to early Pleistocene period, the diet of early hominins was extremely high in fiber, plant sterols, and vegetable proteins (Jew et al. 2009: 927; Bellisari 2016: 61). This diet lacked animal proteins, and early hominin bodies would not have the appropriate energy deposits required to meet the demands of a large-brained and physically active human body (Bellisari 2016: 58). The human brain has an obligatory energy demand that does not shrink during periods of starvation. An adult human brain requires between 280-420 calories per day, which is approximately 20-30% of the body's energy budget (Leonard and Robertson 1994: 85; Aiello and Wells 2002: 328; Leonard 2002: 108; Peters et al. 2010: 1349; Lieberman 2013: 131). During periods of negative energy imbalance, the body will draw energy from fat reserves to meet the energetic demands of brain function (Wells 2010: 180; Bellisari 2016: 58). Transitioning into the Palaeolithic period, early humans began to incorporate high amounts of animal protein from lean meat and seafood into their diets (Jew et al. 2009: 927). This high-quality meat based diet was better equipped to meet the energetic demands of large-brained human bodies (Bellisari 2016: 58). Scholars also believe that the discovery of fire allowed humans to begin cooking their food, a process which yields a greater number of digestible calories and other nutrients (Leonard 2002: 111; Leonard et al. 2003: 13; Milton 2003: 3891S; Navarrete et al. 2011: 92; Lieberman 2013: 135).

A hypothesis developed by researchers to explain the selection for fatness aiding brain development is termed "survival of the fattest", which argues that the fittest early humans were the fattest infants, as the fat depots served as energy reserves that allowed the brain to increase in size (Cunnane and Crawford 2003: 21). This theory explains the need for early hominins to begin dedicating constant energy and nutrient to the brain to promote encephalization and aid in survival (Cunnane and Crawford 2003: 19). Human babies benefit from ample fat reserves to ensure they can provide enough energy to their rapidly developing brains (Cunnane and Crawford 2003: 21; Lieberman 2013: 276). Additionally, the body fat in neonates and infants fulfills the energetic requirements of brain development and protects against muscle loss during periods of famine (Bellisari 2016: 57). While adults spend 20-30% of the body's resting energy budget on brain function, infants will spend approximately 60% of their energetic budget (Kuzawa 1998: 185; Leonard et al. 2003: 12; Lieberman 2013: 131). As a response to the increased need for fat deposits on the infant body, the last trimester of pregnancy is devoted to fattening the fetus. The fetal brain triples in mass during the last three months, and fetal fat stores increase 100-fold (Lieberman 2013: 132). Among terrestrial mammals, the capacity to transfer maternal fat depots onto the fetus' body during pregnancy is apparently a uniquely human feature (Cunnane and Crawford 2003: 22).

Reproductivity

Body fat content and reproductive functions are strongly correlated (Wells 2010: 172); however, the majority of literature linking adiposity with fertility usually focuses on fertility in females rather than in males. Fatness is often viewed as an adaptation towards successful completion of pregnancy (Brown and Konner 1987: 38), and gluteal and femoral adipose deposits are widely associated with fertility and reproductive success. The female body allocates fat deposits towards gluteal and femoral areas, and this is because subcutaneous fat on the lower body is more efficiently mobilized during pregnancy and lactation, whereas upper body fat is utilized for everyday energetic needs (Ulijaszek and Lofink 2006: 342). This would explain why females store excess fat as subcutaneous tissue in the lower body, while males store it abdominally in the upper body. Because adiposity plays a greater role in relaying fitness in females than in males, some scholars argue that female fat deposits became sexually attractive by cluing males to the reproductive value of a female (Pawowski 2001: 572; Wells 2010: 187).

Reproductive function is generally deferred or interrupted when dietary energy supply is constrained or when competing physiological functions increase their own demand (Wells 2010: 174). Because vital organs such as the brain have obligatory energy demands, the body will experience a tradeoff where reproduction is sacrificed in a response to meet more crucial biological needs. Negative energy balances and low body fat levels can therefore result in the delay or cessation of ovulation among women (Brewis 2011: 36). Clinical observations have indicated that women with less than 20% of body fat are unable to menstruate and have decreased chances of conceiving (Tripp and Schmidt 2013: 55). Potential mothers in subsistence economies are less likely to conceive when they are losing weight, as food is limited and individuals are constantly physically active (Lieberman 2013: 276). If a normal weighted woman in subsistence economies loses one pound over the course of a month, her ability to get pregnant declines considerably in the subsequent month (Lieberman 2013: 276). When energy intake is constrained, pregnancy may induce little to no weight gain, as energy is taken from subcutaneous lower fat deposits which results in fat loss (Wells 2010: 113). A pregnant woman must consume enough calories to nourish herself and her fetus (Lieberman 2013: 276). The risk of miscarriage and stillbirth increases among malnourished women, and this is considered an adaptive strategy prioritizing survival over reproduction (Wells 2010: 173).

The energy costs of lactation are substantially higher than the energetic costs of pregnancy. Gluteal and femoral fat deposits that are accumulated during female adolescence and pregnancy aid in supplying to the energy burden of lactation (Wells 2010: 115, 176; Bellisari 2016: 49). Researchers indicate that these gluteal and femoral fat stores decrease during the process of lactation while lean mass remains stable, demonstrating that energy from subcutaneous adipose stores is preferentially utilized (Wells 2010: 116). The quality of adipose tissue used for lactation costs is also important; moreover, the gluteal and femoral adipose deposits contain a high proportion of long-chain polyunsaturated fatty acids (Wells 2010: 176). These fatty acids are critical for neural development in the offspring, and these acids are transferred from the mother to the infant during the process of lactation (Kuzawa 1998: 185; Wells 2010: 176). Additionally, maternal fat deposits provide the necessary energy required for producing milk during periods of maternal malnutrition (Wells 2010: 176).

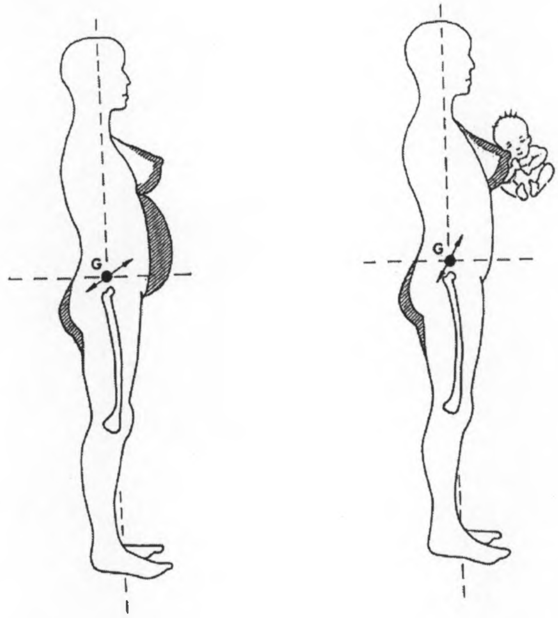


Figure 3.2. Demonstration of how the location of female fat deposits serves to maintain the body's center of gravity during [left] and after [right] pregnancy (Pawowski 2001: 573)

While gluteal and femoral fat deposits are often regarded as adaptations favoring fertility, an alternative hypothesis describes these adipose deposits as a mechanical rather than reproductive adaptation. Researchers believe that these fat deposits may serve to counterbalance weight gain achieved during pregnancy that would have offset their center of balance (Pawowski 2001: 573; Nuttall 2015: 121). This evolutionary trait would have occurred after the emergence of *Homo*, where bipedal locomotion became obligatory rather that occasional (Pawowski 2001: 574). Pregnancy shifts the center of gravity upward and forward, and this shift would have created mechanical problems in walking forward. Evolution could have selected for adipose deposits to be positioned posteriorly to and below the center of gravity in order to counterbalance the shift in weight (Pawowski 2001: 574). This would explain why weight gain occurs throughout pregnancy, as it is assumed to aid in rebalancing the body as the fetus continues to develop. Without this counterbalance, inefficient walking and foraging would have created the risk for starvation and predation among bipedal females (Pawowski 2001: 574).

Immune Function

While over half of energetic demands are relegated to the development of the brain in infants, energy is also directed towards immunity against pathology. The development of adipose tissue in humans is often referred to as an advantageous adaptation that improves the immune system and protects against deadly bacterial infections such as tuberculosis (Brewis 2011: 38). Humans are highly sensitive to burden of infection during infancy and early childhood, as the immune system is exposed to pathogens for the first time (Kuzawa 1998: 180; Wells 2010: 183). Affliction of infection also results in a general decrease of energy intake, which further weakens the ability to protect against infections (Wells 2010: 179, 185). Therefore, adipose tissue provides energy that could be used in fighting against diseases. The accumulation of energy as fat deposits could be a response among early humans living in environments of scarcity, as impaired nutritional status may increase vulnerability to infectious disease (Wells 2010: 187). Adipose tissue secretes cytokines, which are groups of signaling proteins that trigger pro-inflammatory and anti-inflammatory responses (Wells 2010: 70). Pro-inflammatory cytokines induce inflammation and cause tissue destruction, whereas anti-inflammatory cytokines contribute to wound healing and deep-tissue recovery (Wells 2010: 70). Secretion of these cytokines thus links adipose tissue with immune function, as energy is taken from these stores and utilized for these immune processes (Wells 2010: 70, 187).

Ecological Stresses

A widely-accepted theory among obesity researchers is that the emergence of body fat resulted from the stresses of famine and energy stochasticity experienced by early hominin populations. Researchers argue that early humans regularly endured a lack of food resources; consequently, the scarce environmental conditions would have significantly impacted natural selection in human evolution (Brown and Konner 1987: 30). Palaeolithic hunter-gatherers frequently faced periodic food shortages, and scholars argue that the storage of energy as adipose depots is advantageous among archaic humans who were required to expend large amounts of energy while engaging in foraging strategies (Pontzer 2012: S356; Lieberman 2013: 276; Bellisari 2016: 23). Because Palaeolithic hunter-gatherer communities did not have a stable source of food resources, bodily fat stores would have allowed for accommodation during famine periods where energy supply does not match energy needs (Racette et al. 2003: 280; Wells 2010: 162; Raisborough 2016: 26). Researchers also believe that early humans were selected to crave energy-rich foods in order to promote a positive energy balance that would promote the storage of fat as adipose deposits (Heitmann 2012: 918; Lieberman 2013: 181). Additionally, populations practicing farming strategies are most vulnerable to seasonal variability in energy supply, as they are unable to relocate during times of energetic stress (Wells 2010: 162). The stresses faced by farming communities may pinpoint an increase in the selection for human adiposity during the Neolithic Revolution, which is a period attributed to the rise of agriculture.

However, some scholars argue that the theory that famine as the primary selective pressure favoring fat stores in humans is problematic. This theory assumes that death from starvation was the primary cause of mortality during famine conditions, and it does not consider other possible reasons for death during ecological stress such as age or disease-related factors (Wells 2010: 154). An alternative hypothesis that accounts for these factors would be that during periods of famine, humans who were not susceptible to infectious diseases survived longer as their increased energy reserves provided by adipose depots (Wells 2010: 154).

Fatness is also believed to function as an insulator against cold climates (Lieberman 2013: 132; Bellisari 2016: 85; Kirchengast 2017: 40). During the last trimester of pregnancy, fetal body fat content increases from 3-5% to approximately 12-15% of body mass at birth (Barness et al. 2007: 3019). In addition to aiding various other biological functions, this increase of fatness may have been selected to prepare human offspring to the thermoregulatory stress that results from the exposure of the large skin surface area to air during the first days following birth (Wells 2010: 183).

Summary

Human adiposity is a physiological trait that was selected based on its benefits in meeting the energetic demands of human biological function while also increasing human brain size, reproductivity, immune function, and survival during periods of scarcity. Analyzing human adiposity from an evolutionary perspective demonstrates the storage of energy as adipose tissue as an adaptive strategy that persisted throughout human evolution. The majority of theories indicate a strong focus on fatness among women likely due to the importance placed on reproduction and survival of *Homo sapiens.* This analysis is necessary in order to explain how the selection for human adiposity plays a role in possible causalities obesity.

Chapter 4: Causes of Obesity

The emergence of obesity is often attributed to an energy balance model where energy intake must exceed energy expenditure to produce bodily fat deposits (Colls and Evans 2014: 737; Barness et al. 2007: 3019). However, the explanation for the emergence of obesity is much more complex than simple calorie-in versus calorie-out models and requires a deeper analysis of the interaction between human biology and the surrounding environment (Lieberman 2013: 280). The evolutionary perspectives on the emergence of adipose tissue as energy stores in humans provides researchers with possible explanations for the accumulation of human adiposity. These explanations will aid in better understanding the possible causalities of obesity. This chapter will discuss biological influences of obesity including the effects of genetics and hormonal imbalances. The first section of this chapter will provide a description of hypotheses and research regarding genetic predisposition for the expression of obesity, such as the thrifty genotype hypothesis. The second section will describe how hormonal imbalances influences obesity by altering physical activity, food consumption, and fat storage. The following section analyzes the mismatch hypothesis, which asserts that evolutionary adaptations promoting large fat stores in humans is no longer advantageous in modern obesogenic environments. The last section elaborates further on obesogenic environments by presenting case studies that demonstrate the effects of these environments on modern human bodies.

Genetic Influences

Researchers have argued that human evolution has influenced the genetic predisposition towards maximizing energy input while reducing energy output in order to save energy in adipose stores (Bellisari 2016: 85). Genetic research indicates that only a few genes have a major impact on the expression of obesity; however, there are larger numbers of susceptibility genes that impact weight gain and fat distribution in humans (Bray 2015: 349). Research on the possible genetic contributions towards the emergence of obesity has resulted in the discovery of over 600 genes, markers, and chromosomal regions that are associated with human obesity phenotypes (Ulijaszek 2006: 183).

A frequently debated hypothesis on the genetics of obesity is the thrifty genotype hypothesis. This hypothesis proposes that natural selection among archaic humans favored "thrifty" genes that promoted the storage of energy acquired from feasts as fat for future use in hostile and scarce environments (Neel 1962: 353; Nadler 2001: 86; Barness et al. 2007: 3022; Brewis 2011: 38 Wells 2012: 596; Lieberman 2013: 277). Genetic predisposition towards efficiently storing energy is dependent on ancestral exposure to periods of scarcity and abundance (Wells 2012: 596). Consequently, genes become thriftier with increased exposure to stressful ecological conditions (Wells 2012: 596). The thrifty genotype hypothesis originally attempted to explain the prevalence of diabetes mellitus type II; however, researchers have utilized this theory in order to explain excessive weight gain in modern humans (Brewis 2011: 37). An influential genetic discovery that supports the thrifty genotype hypothesis is that of the FTO (fat mass and obesity associated) gene on chromosome 16, which is strongly associated with body fatness and BMI (Barness et al. 2007: 3022; Brewis 2011: 38; van der Klaauw and Farooqi 2015: 126). Approximately 16% of adults who exhibit an identical pair for the same gene (homozygosity) for this at-risk allele weighed about 6.6lbs more compared to not-at-risk individuals, and they also expressed a 1.67-fold increased risk in being diagnosed as obese (Barness et al. 2007: 3023). Researchers assert that the FTO gene long precedes the rise in human obesity, which indicates that the predisposition to become obese was always present among humans (Lieberman 2013: 285).

However, the thrifty genotype theory has been criticized as an oversimplified analysis of physiological adjustments involved in the transition from Palaeolithic to industrialized lifestyles. This hypothesis relies on the assumption that obesity is advantageous and under positive selection pressures; however, research analyzing obesity using Haldane's selective advantage of 0.001 indicates that thrifty genes favoring obesity would be expressed in almost every modern human (Speakman 2008: 1612). An alternative hypothesis is the "drifty" genotype theory, which argues that genes favoring obesity have not been positively selected but were rather subject to random drift due to neutral selection pressures (Speakman 2008: 1611; Wells 2012: 597-598). Researchers have theorized that genetic drift would have contributed to the accumulation of alleles related to adiposity over millions of years; consequently, human adiposity is now easily expressed due to the influence of modern obesogenic environments (Speakman 2008: 1615; Wells 2012: 597-598). Speakman provides an example where body fatness is regulated by upper and lower intervention limits, where the lower limit is set by risk of starvation and upper limit is set by risk of predation (Speakman 2008: 1615). Modern societies have freely available energy, and this environment allowed individuals to drift their upper intervention points and express an obese phenotype (Speakman 2008: 1615). The phenotypic expression of obesity is exacerbated among societies adjusting to modernized environments, as these environments provide continuous access to calories while also promoting a sedentary lifestyle due to technological advancements (Pollock 1995: 357; Nadler 2001: 86; Barness et al. 2007: 3022; Bellisari 2016: 86).

A contrasting theory is the thrifty phenotype hypothesis, which explains the emergence of obesity as a result of epigenetic factors experienced in-utero and in early infancy. This hypothesis argues that babies experiencing low nutrient supplies in-utero will develop a lowered metabolic rate, grow more slowly, and have smaller bodies that are better adapted for an environment of food scarcity (Brewis 2011: 41; Wells 2012: 596). Underdevelopment in-utero occurs as an adaptation against an environment of food scarcity, but these nutrient-saving strategies result in increased risk for obesity once food resources become stable (Ofei 2005: 99). The thrifty phenotype hypothesis predicts that babies born in developing countries are at an increased risk of developing obesity due to the frequent food shortages experienced in these regions (Brewis 2011: 41). Poor fetal and infant growth has also been linked with impaired glucose tolerance and increased risk for metabolic syndrome during adulthood (Hales and Barker 2001: 5).

Researchers also assert that obesity prevalence among humans is affected by assortative mating. Assortative mating is the process in which individuals select a mate based on phenotypic similarities. Humans are expressing obesity at younger ages, and obese children are more likely to grow into obese adults compared to non-obese children (Ofei 2005: 99). Adults are also getting married at older ages, which allows for obese humans to select obese partners. This selection allows the at-risk recessive alleles associated with obesity to become concentrated in offspring of successive assortative mating (Heitmann et al. 2012: 917-918; Bellisari 2016: 103). However, the roles of genetic factors in obesity are complex, as they involve the interaction between many genetic components that individually may have relatively minor effects (Wells 2010: 58).

Hormonal Imbalances

Because adipose tissue acts on immune function and reproductive function, it contains receptors for a wide range of biochemical factors including leptin, insulin and glucagon, vitamin D, thyroid hormone, glucocorticoid, sex hormones, cytokines, and catecholamines (Wells 2010: 72; Legiran and Brandi 2012: 147). Research frequently cites specific aspects of human behavior as associated with weight gain; however, researchers will overlook the deeper underlying biological mechanisms that promote weight gain through specific activities (Wells 2010: 81). Further analysis on the hormonal influences will demonstrate the biological origins of obesity which also explains why obesity is often linked with behavioral activities and psychosocial states.

Leptin is a 16kDa peptide hormone that is the product of the *ob* (obese) gene and is strongly associated with fat mass (Grunfeld et al. 1996: 2152; Wabitsch et al. 1996: 1435; Rühli and Henneberg 2002: 379; Ofei 2005: 99). Leptin functions in signaling the hypothalamus regarding energy depletion, and feelings of satiety are released accordingly (Tritos and Mantzoros 1997: 1375; Rühli and Henneberg 2002: 379; van der Klaauw and Farooqi 2015: 121). While fat cells secrete leptin hormones in order to signal satiety and suppress appetite (Wabitsch et al. 1996: 1435; Klok et al. 2006: 22), ghrelin hormones are secreted by the stomach and pancreas in order to stimulate appetite (Klok et al. 2006: 24; Lieberman 2013: 285-286; Rühli and Henneberg 2013: 115; Heisler and Lam 2017: 103). Research indicates that alterations to the strength of or sensitivity to leptin and ghrelin will affect dietary intake and adiposity levels (Friedman 2004: 565; Bastard et al. 2006: 5; Myers et al 2010: 649). Lower leptin concentrations have been associated with low-calorie diets, whereas high-calorie diets characteristic of obesity is linked to increased leptin concentrations (Legiran and Brandi 2012: 146).

High levels of body fat produce high concentrations of leptin, which results in stronger feelings of satiety and decreased food intake (Rühli and Henneberg 2002: 379). Adipose tissue determines leptin concentrations in the body, and higher adipose levels will increase leptin secretion (Tritos and Mantzoros 1997: 1373; Heisler and Lam 2017: 103). Subcutaneous adipose tissue secretes higher levels of leptin compared to visceral adipose tissue; moreover, women express increased leptin levels due to higher subcutaneous levels of fat (Minocci et al. 2000: 1142-1143; Pan et al. 2014: 159). Sex hormones such as estrogen and testosterone also influence leptin levels due to their effect on body fat allocation. Estrogen inhibits fat deposition in the abdominal region while favoring deposition in the gluteal-femoral regions, and testosterone produces an inverse effect (Singh 2002: 82; Singh and Singh 2011: 725). The relationship between leptin and adipose tissue results in higher leptin concentrations among obese individuals (Wabitsch et al. 1996: 1435; Ofei 2005: 99). Researchers hypothesize the high levels of leptin in obese bodies indicates resistance to leptin, possibly due to defects in leptin signaling (Bjørbaek 1998: 619; Friedman 2004: 565; Myers et al. 2010: 1). Another theory hypothesizes that leptin resistance emerged as a response to harsh environmental conditions that would have promoted increased food intake, decreased energy expenditure, and increased fat storage (Rühli 2002: 380; Friedman 2004: 568; Myers et al. 2010: 1).

A major change experienced by *Homo sapiens* is the rising levels of stress, which contribute to weight gain (Lieberman 2013: 285). The adrenal glands release a small dose of the hormone cortisol during periods of stress, and this biochemical activity within the human body is considered to be an ancient adaptation that emerged in order to allow early humans to experience a burst of energy to flee from predators and other potentially dangerous situations (Lieberman 2013: 285). Cortisol causes liver and fat cells to release glucose into the bloodstream, which increases alertness and heartrate while inhibiting sleep (Lieberman 2013: 285). High cortisol levels are induced by elevated stress levels, which results in sleep deprivation and further increases cortisol levels (Lieberman 2013: 286). Chronically high cortisol levels are associated with lowered immunity responses, growth interference, and increased risks of abdominal obesity and diabetes mellitus type II (Lieberman 2013: 250; Dhurandar 2016: 91). High cortisol activity is also associated with leptin resistance, which is known to suppress energy expenditure, increase appetite, and contribute to weight gain (Wabitsch et al. 1996: 1436; Tritos and Mantzoros 1997: 1375; Dhurandar 2016: 91).

During normal sleep patterns, leptin levels rise while ghrelin levels decline in order to prevent the human body from becoming hungry and waking up (Lieberman 2013: 250-251). Consistent lack of sleep results in the decline of leptin levels and the increase of ghrelin levels, effectively signaling a state of famine to the brain (Wells 2010: 81; Lieberman 2013: 251). The inhibition of leptin responses is also induced by high levels of insulin, which triggers a sense of starvation, induces hunger, and promotes sedentism (Lieberman 2013: 286). The anticipation of food illicit several metabolic responses, such as the production of an initial wave of insulin secretion that occurs before blood-glucose levels rise (Wells 2010: 82). This discovery provides insight as to how social cues may impact the physiological regulation of appetite. Modern humans live in a realm of changing living conditions, where they are more prone to becoming overstressed and to lacking adequate sleep; moreover, these behaviors produce hormonal responses to buffer inadequate rest and contribute to weight gain (Lieberman 2013: 285; Rühli and Henneberg 2013: 115).

Mismatched Hypothesis

The interaction between genetic and non-genetic factors has resulted in the development of the mismatched adaptation theory. The mismatched hypothesis states that adaptations that were once selected as advantageous are now considered mismatched adaptations (Leonard 2002: 106; Lieberman 2013: 181). Mismatched adaptations are caused by stimuli that have become excessive, restrictive, or are new. Within the context of fat and obesity, chronic illnesses may result from eating too little fat, too much fat, and new kinds of fat that the body cannot digest such as partially-hydrogenated fats (Lieberman 2013:183).

Obesity prevalence suggests an environment more permissive to expression of genetic tendencies which may have been advantageous to ancestors in more hostile environments (Barness et al. 2007: 3022; Lieberman 2015: 182). Obesogenic environments are ecologies with specific physical, social, cultural, and economic characteristics that disrupt the body's natural energy balance and contributes towards the propensity for excessive fat storage (Ulijaszek 2006: 184; Brewis 2011: 48; Colls and Evans 2014: 733). These ecologies refer to the modernized environments associated with industrialized nations, and these environments are commonly associated with negative health effects (Leonard 2002: 106; Ulijaszek 2006: 184; Hruschka and Hadley 2008: 948). As illustrated by an evolutionary analysis of human adiposity, the capacity for the accumulation of fat was considered an advantageous adaptive feature among early *Homo*. However, this once advantageous adaptation is now considered detrimental for humans living within obesogenic environments where energy supply is abundant and physical activity is minimized due to technological advances (Bindon and Baker 1997: 202; Leonard 2010: S284; Myers et al 2010: 648; Brewis 2011: 42). Excessive human adiposity is now best described as a physiological struggle against modernity (Chaput et al. 2012: 681).

The interaction between human genetics and the environment has been impacted by rapid cultural evolution, which has contributed to the emergence and prevalence of numerous health problems and chronic diseases (Myers et al. 2010: 648; Lieberman 2013: 182; Bellisari 2016: 103). Palaeolithic humans were selected to crave high calorie foods, which were rare in an environment of scarcity; however, advantageous foods are in abundance in modern environments (O'Keefe and Cordain 2004: 103; Heitmann at al. 2012: 918). Humans are expressing greater measures of abdominal obesity due to the consumption of too many calories, especially from glucose and fructose sugars. While archaic humans evolved to seek sugar as a source of energy, modern humans are consuming sugar in doses that are both too high and too rapid for the digestive system inherited by *Homo sapiens* (Heitmann 2012: 918; Lieberman 2013: 283). Energy-dense foods are now accessible to humans living in industrialized environments, which promotes obesity (Ulijaszek 2006: 185; Heitmann 2012: 918; Lieberman 2013: 292; Kirchengast 2017: 42; Albuquerque et al. 2017: 164). Medical studies have linked obesity with chronic diseases such as metabolic diseases such as type II diabetes, cardiovascular diseases, and reproductive cancers (Leonard 2010: S284; Lieberman 2013: 287). Body fatness among prehistoric women was selected for increasing fertility, yet modern obesogenic environments result in excess storage of body fat which is associated with reproductive complications including menstrual dysfunction, anovulation, and miscarriage (Ulijaszek 2006: 184).

Agriculture emerged between 10,000-3,000 years ago in different geographic regions, and foraging humans settled in agricultural communities in order to produce a dependable source of high-calorie food resources that allowed for the development of larger population communities (Bellisari 2016: 67; Kirchengast 2017: 41). Although agriculture produced food surpluses that reduced food shortages, the nutritional value of agricultural crops was of much lower quality compared to the wild plant resources consumed by foraging hunter-gatherer groups (Neel 1999: S4; Bellisari 2016: 67). Regardless, agriculture established the foundation for early human civilization and ultimately for modern industrial life (Bellisari 2016: 65). Agriculture produced enough food resources to allow individuals to specialize in non-food goods and technologies, and this specialization would have allowed for technology to evolve as non-food specialists are supported by agricultural resources (Weisdorf 2005: 578).

Rapid technological transitions also increase the prevalence of obesity by promoting a decrease in physical activity expenditure (Neel 1999: S5; Schultz 2017: 241). The effect of technological advancements on human body fatness is evidenced by the increase in sedentarism caused by the Industrial Revolution. The use of labor-saving technologies has transformed modern agricultural conditions into obesogenic environments (Bellisari 2008: 173; Kirchengast 2017: 37). Pre-industrial agricultural societies engaged in large amounts of physical exertion, and data suggests that these people sat for approx. 300 minutes/day whereas modern humans working in sedentary environments remain sitting for up to 15 hours/day (Levine 2015: 1751). Obese individuals are found to spend 2.5 more hours a day sitting compared to leaner people with similar professions, economic statuses, and home environments (Levine 2015: 1752). Excess sitting is also found to disrupt sex hormone function, insulin-like growth factors, inflammation and vitamin handling (Levine 2015: 1752). Many studies have also associated television viewing with obesity, but this connection is based on the hormonal responses that occur while remaining sedentary; moreover, lack of physical activity results in low metabolic rates while also increasing appetite levels (Wells 2010: 81).

Obesogenic Environments, Moralized Ecologies

Researchers have conducted studies on indigenous communities in modernized environments in order to identify lifestyle and social factors that may contribute to the increasing obesity rates among these populations. Bersamin and colleagues focused their study on the activity patterns of the indigenous Yup'ik populations of the YK Delta region of Alaska (Bersamin et al. 2013: 258). These populations are impacted by high stress loads resulting from historical trauma and forced acculturation; moreover, these stressors have been linked with obesity, diabetes mellitus type II, and cardiovascular diseases (Bersamin et al. 2013: 256). The loss of traditional lifestyles and psychosocial stresses are co-occurring with a sedentary lifestyle, and this is the result of the federal government restricting these communities from engaging in traditional subsistence strategies (Bersamin et al. 2013: 256). The authors surveyed 488 (284 non-pregnant women, 204 men; 14+ years of age) Yup'ik Eskimos living in seven remote communities in the YK Delta region of Alaska, and 261 of these participants completed a pedometer study to measure every-day physical activity (Bersamin 2013: 258). This study indicated that Yup'ik people who lived a more traditional lifestyle and had lower levels of psychosocial stress were more physically active, and it is suggested that enculturation may have positive impacts on important health behaviors (Bersamin 2013: 258). This study asserts that public interventions aiming to increase physical activity to reduce obesity prevalence would be more successful if they incorporate local cultural contexts (Bersamin 2013: 262).

A similar study is Wiedman's analysis of metabolic syndrome among contemporary Native American populations. Metabolic syndrome is the cluster of obesity, diabetes, dyslipidemia, and hypertension, and American Indians and South Pacific indigenous people were some of the first groups of people who experienced this epidemic in the 1940's (Wiedman 2012: 596). Wiedman utilizes ethnohistorical methods in order to analyze the history of metabolic syndrome among Native American groups such as the Kiowa, Comanche, and Apache communities. The history of Native American groups reveals a period (1860-1930) of extreme psychosocial stresses from assimilating to the policies of the Federal Government. The U.S. military fought and defeated indigenous populations and gained control over their land and resources; consequently, the Kiowa, Comanche, and Apache communities became dependent on government supplies to survive (Wiedman 2012: 599). The U.S. government worked to contain the indigenous populations within reservation boundaries, which prevented communities from engaging in traditional hunting practices (Wiedman 2012: 599). The long history of oppression and domination experienced by Native American groups resulted in post-traumatic stress syndrome which is associated with cardiovascular diseases and other health related disorders (Wiedman 2012: 602). Although individuals have agency to make decisions that will prevent the diagnosis of metabolic syndrome, these decisions are actively influenced by political restrictions and incentives (Wiedman 2012: 606).

The concept of obesogenic environments is problematic in that they perpetuate the moralized discourses regarding fat bodies and their surrounding environments. The determinants of obesogenicity are biased, as they generally refer to high socioeconomic status and reproduce privileged ideologies regarding the desirability of an environment and its inhabitants (Colls and Evans 2014: 741). Researchers who link obesity with ideas of socioeconomic status tend to perpetuate ideas that obesity reflects wealth in non-western nations, while reflecting poverty in industrialized nations (Ulijaszek 2006: 184). Researchers who promote these ideas ascribe generalized meanings onto the condition of being obese within specific environments. Obesogenic ecologies often refer to environments associated with specific racial or ethnic groups (Colls and Evans 2014: 741). This is demonstrated in studies where researchers assume that excess fatness in white societies is inferior for white standards, whereas fatness in black communities is not viewed as lack of control but rather as a means in which control is attained (White 2013: 328). Obesogenic models are used to pathologize the body, which marginalizes entire population groups that happen to reside in an environment that may be deemed obesogenic by researchers.

Summary

Theories surrounding the origins of obesity are commonly linked to the possible genetic influences that predispose humans to the risk of excess fat accumulation. Theories such as the thrifty genotype, drifty genotype, and thrifty phenotype explain that the biological adaptations which emerged to increase fitness in environments of scarcity are now mismatched to the modern environments where energy is abundant and physical activity is decreased. Hormones such as leptin, ghrelin, and cortisol are also observed to influence behavioral actions that alter food intake and energy expenditure. While analyses on the genetic and hormonal influences of obesity attempt to explain the origins of this physical condition, an analysis on the skeletal remains of archaeological populations may provide further insight on whether these groups accumulated excess body weight.

Chapter 5: Body Mass Estimation

As discussed in chapter 2, an academic study on obesity will require consideration of the scientific measures that define obesity. Therefore, an archaeological analysis of obesity will require a method that directly identifies body mass index from human remains. Because soft adipose tissue does not preserve in the fossil record, archaeological obesity research will require an analysis of the effects that excess body weight has on the human skeletal system (Walker et al 2017: 2). Recent analysis of the osteological responses to excess body weight has allowed researchers to develop body mass estimation (BME) techniques. Research on the morphological and compositional bone responses to varying levels of body weight will allow greater insight in identifying obesity in archaeological samples. This chapter is organized into five sections. The first section describes the osteological processes of modeling and remodeling, and this section is necessary in understanding the second section on the biomechanics of obesity. This second section will focus on the specific skeletal changes that occur in response to obese bodies. The third section presents studies that attempt body mass estimation techniques on contemporary human skeletal samples, while the fourth section continues to describe the limitations of these techniques and how it may affect an archaeological analysis of obesity. The last section describes how BME methods have been applied in bioarchaeological studies in order to better understand the biological, ecological, and behavioral changes experienced by early hominins.

The Osteology of Obesity

The human skeleton serves a variety of functions, such as supporting body weight. Developmental stages in human life history will require the skeletal system to adapt to the physical and environmental changes accordingly. The plasticity of bone encourages physical alterations to occur during the processes of bone modeling and remodeling, and bone deformation (strain) is stimulated as a response to experiences of stress or applied force (Ruff et al. 2006: 485; Moore 2009: 16). Bone modeling includes the processes of bone resorption and formation on opposing bone surfaces (Wheeler et al. 2015: 1049). Resorption requires the work of osteoclasts, which are large multinucleate bone cells that break down existing bone to release new minerals and remove organic waste (Moore 2009: 27). Osteoblasts are cells that create new bone matrix by secreting osteoids, resulting in bone formation (Moore 2009: 27). Osteoblasts eventually mature into osteocytes, and these new bone cells are actively involved in bone turnover processes and can indicate when bone modifications are necessary in order to accommodate specific mechanical forces (Moore 2009: 27). Additionally, modeling occurs during growth and developmental periods and increased long bone length, diameter, and bone mass (Wheeler et al. 2015: 1049). Developing juveniles have a higher percentage of collagen in their bones; therefore, their bones (especially the joining epiphyses) can adapt more efficiently to its environment (Moore 2009: 21).

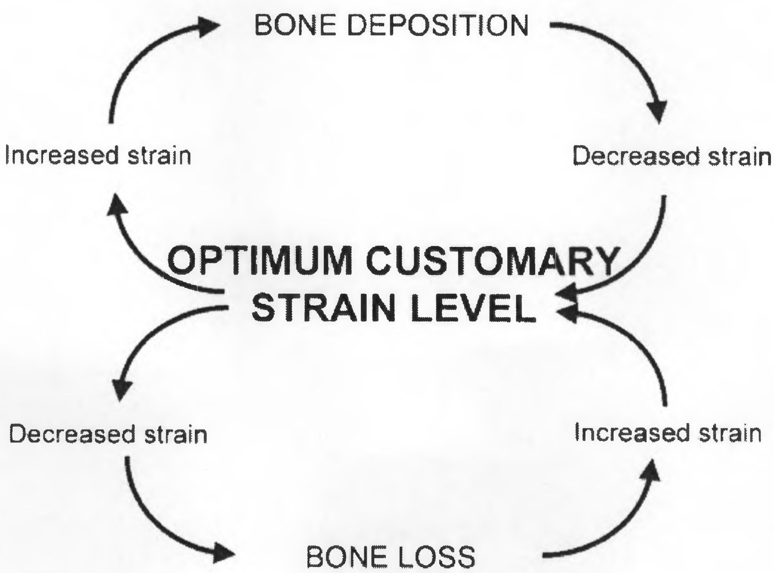


Figure 5.1. Bone responses based on strain type (Ruff et al. 2006: 485)

Bone remodeling is the replacement of old bone tissue with new bone tissue and occurs as a response to load bearing or skeletal trauma primarily in the adult skeleton

(Wheeler et al. 2015: 1049). Load bearing is a biomechanical property that influences remodeling activity in the skeleton, and strain resulting from excess body weight will typically affect the morphology of the lower limbs rather than the upper limbs (Moore 2009: 3; Harrington and Wescott 2015: S33). This is based on the fact that the major joints of the legs are exposed to loads that are 1.9 to 7.2 times body weight (Moore 2009: 5). Bones can be loaded by tension, compression, shear, and bending forces (Moore 2009: 4), and different levels of strain will result in specific bone remodeling processes as illustrated in Figure 5.1. Bone adapts to strenuous loadings by altering its geometry accordingly (Ruff et al. 2006: 490). During remodeling, secondary osteons will overlay the primary lamellar bone; moreover, remodeling stops once the load threshold is brought back down to normal strain levels (Moore 2009: 21). An increase of physical activity will result in increased strain levels, and this will induce bone deposition to reduce strain levels (Ruff et al. 2006: 485). Frequent physical inactivity will result in decreased strain levels and cause the resorption of bone tissue in order to keep a balanced skeletal strain threshold (Ruff et al. 2006: 485). Loading of adult bones can illicit different responses over time; however, bone responses to strain can vary based on the types of strain, skeletal location, age, disease, hormonal status, and genetic background (Ruff et al. 2006: 485-486). Controlling for genetic influences on bone form in research studies occurs by limiting comparisons of bone shapes to similar skeletal locations in closely related species (Ruff et al. 2006: 495). Additionally, researchers should also note other variables such as diet and hormonal status when interpreting bone structure (Ruff et al. 2006: 495).

These skeletal responses to strain experienced by load-bearing limbs are also known as bone functional adaptations (Agostini and Ross 2011: 339). The theory of bone functional adaptation stems from the earlier concept of Wolff's law, which states that bone remodeling of the internal architecture and external form of the bone is specifically governed by mathematical rules (Ruff et al. 2006: 485). Wolff's law has been subject to criticism as it relies on the assumption that bones are solid, homogenous, and isotropic structures that are subjected to static loads (Ruff et al. 2006: 485). However, the function of the human skeleton is not purely mechanical, and its mass and morphology represents a compromise in meeting different physiological demands (Ruff et al. 2006: 494). While Wolff's law is heavily criticized, academics accept Wolff's more general ideas regarding the important role that mechanical loading plays in bone development and modeling. The generalized version of Wolff's law is referred to as bone functional adaptation, which explains how bone will reinforce itself along the direction of principal strain (Moore 2009: 16). Researchers have argued that bone functional adaptation should completely replace Wolff's law (Ruff et al. 2006: 485).

The Biomechanics of Obesity

Previous research indicates that the condition of obesity affects the long bone diaphysis of load-bearing elements by increasing cross-sectional area, robusticity, and strength (Wheeler et al. 2015: 1049). Other studies have indicated that an increased BMI will influence the shape of specific load bearing variables such as the knee (Agostini and Ross 2011: 339). The femur is thought to become more round with an increased BMI and may indicate a sedentary lifestyle (Godde et al. 2013: 303e.2). As weight increases, alterations to the femoral angle will result in greater mediolateral pressures which force the femur to either adapt accordingly or risk being fractured (Agostini and Ross 2011: 341). Body mass estimates for obese individuals would result from a thick cortical area with a round and narrow shaft diameter (Moore 2009: 7). Greater axial loads will produce thicker cross-sectional areas in order to accommodate these loads (Moore 2009: 16). Because obese humans regularly experience much greater axial loads compared to normal-weight humans, thicker and circular cross-sectional areas are representative of obese individuals (Moore 2009: 15).

Greater bending strength in a certain direction indicates that that bone is often more loaded in this specific direction (Moore 2009: 15). The sit-to-stand and gait patterns of obese individuals are affected by their excess body weight. Overweight individuals will slide their feet dorsally before rising in order to limit the flexion of the torso and lighten the loads on the lower back (Agostini and Ross 2011: 341). Underweight and normal weight individuals will display a pendulous gait, while obese individuals will display a slower and more mediolateral saunter (Moore and Schaefer 2011: 1116). Studies on obese children also indicated that they have a longer cycle duration, longer stance phase, and a slower pace (Moore 2009: 22). They also displayed gait asymmetry and consistently favored their right side (Moore 2009: 22) while also displaying increased hip abduction in order to cope with both weight imbalance and the excess adipose tissue of the inner thigh (Agostini and Ross 2011: 342). Additionally, asymmetry and knee malalignment become common in obese individuals as it serves as a compensatory mechanism in order to counterbalance the excess weight loads (Moore and Schaefer 2011: 1116). This adaptation often leads to knee instability and osteoarthritis.

A study that delves deeper into the biomechanical influences that obesity has on the skeleton is Wheeler and colleagues' 2015 article "The Effects of Body Mass Index and Age on Cross-Sectional Properties of the Femoral Neck". The authors hypothesized that humans experiencing obesity will result in the remodeling of the femoral neck in order to accommodate greater loads associated with an increased BMI. They tested this hypothesis by analyzing computer tomography (CT) scans of 170 random males with known age, sex, ancestry, stature, and weight (Wheeler et al. 2015: 1049). The authors analyzed cross-sectional properties of the bone such as total area (TA) to examine robusticity of the femoral neck and cortical area (CA) which is correlated to axial or compressive strength (Wheeler et al. 2015: 1050). Results indicated that TA did not differ significantly between the normal weight (BMI = 18.5-24.9), overweight (BMI = 25-29.9) and obese (BMI>29.9) categories; however, CA and %CA were significantly greater in in the obese group compared to the normal weight group in the older cohort (over 50 years old) but not in the younger cohort (below 50 years old) (Wheeler et al. 2015: 1054). The authors concluded by stating that obesity overrides age-related changes in bone properties, specifically biomechanical properties when BMI values exceed 30 (Wheeler et al. 2015: 1056). This study illustrates the varying degree to which obesity affects the biomechanical properties of males from different age groups; moreover, the mechanical overloading of load bearing elements seems to increase bone strength which makes the femoral neck less susceptible to fractures in obese individuals (Wheeler et al. 2015: 1056).

Body Mass Estimation Techniques

Osteologists and forensic researchers analyze a range of skeletal characteristics in order to identify a deceased individual's age, stature, and ethnic origins; however, body mass is not considered a significant parameter and is used as supplementary information for the personal identification of an individual (Lorkiewicz-Muszynska et al. 2013: 405.e4). There exist a variety of skeletal variables that are used in estimating body mass including cranial and post-cranial variables; however, post-cranial characteristics are preferable based on the direct relationship to body size or mass (Robson and Wood 2008: 408; Squyres and Ruff 2015: 198). Because body mass estimation from skeletal remains relies on the relationship between mechanical loadings and bone morphology, two types of BME methods utilizing post-cranial characteristics are morphometric and biomechanical techniques (Ruff 2002: 213; Ruff and Trinkaus 2006: 484).

Morphometric analysis relies on basic geometry in order to estimate the overall frame size of an individual. This method calculates body mass by analyzing the allometric relationships between different measurements of the skeleton (Moore 2009: 2). Morphometric analysis models the human body as a cylinder shape, and the estimated stature and bi-iliac breadth are then used to calculate body mass (Ruff 2000: 508; Moore 2009: 2; Squyres and Ruff 2015: 198; Walker et al. 2017: 2). The height of the cylinder is determined by the estimated stature, and the diameter is calculated based on bi-iliac breadth which measures the width of the pelvis (Ruff 2000: 508; Ruff 2002: 213; Moore 2009: 14). This method is generally used to estimate body mass from contemporary deceased humans; moreover, it is not applied to remains from the fossil record due to the lack of preserved os coxae and long bones necessary for this method (Squyres and Ruff

2015: 198). A limitation of the morphometric method is that it provides estimates for general body size and disregards possibilities of robusticity or excess adiposity (Moore 2009: 13).

Biomechanical methods focus on the load-bearing characteristics of the diaphysis and articulations of the weight bearing lower limbs (Holliday 2002: 513; Moore 2009: 13, Squyres and Ruff 2015: 198). Researchers generally estimate body mass in modern humans by analyzing stature, bi-iliac breadth, and femoral head breadth (Lorkiewicz-Muszynska et al. 2013: 405.e1). Femoral measurements are often prioritized by obesity researchers, who argue that the increased axial loads and decreased knee flexion will produce thicker and wider femoral cross sections (Moore and Schaefer 2011: 1116) which is characteristic among obese and severely obese individuals. Femoral head breadth is also commonly used for BME studies because it is frequently available among bioarchaeological samples (Auerbach and Ruff 2004: 331). However, an issue is that the femoral head is part of a ball and socket joint, and has constrained dimension in adulthood and fails to reflect weight fluctuations in adults (Moore 2009: 3). The biomechanical method plugs these skeletal variables into regression equations in order to estimate body mass, and these equations are derived from the regression of body mass on a weight-bearing skeletal dimension from a modern reference sample (Squyres and Ruff 2015: 198). Equations are generally in the form of Y=a+bx, where Y is the estimated body mass, X is the relevant skeletal variable, a is the intercept, and b is the slope of the regression line (Elliott et al. 2014: 201).

Limitations of BME Techniques

The limitations of BME equations lie in failing to identify bodily extremes such as obesity and emaciation. Lorkiewicz-Muszyńska and colleagues' 2013 study "Body mass estimation in modern population using anthropometric measurements from computed tomography" analyze the precision of four BME equations in identifying underweight and obese bodies. The previously published BME equations studied include the Ruff method (sex-specific femoral head analysis), the McHenry method (femoral head analysis), the Grine method (femoral head analysis), and the STBIB method (sex-specific stature/bi-iliac analysis). The authors test these methods by analyzing the multi-slice computed tomography (MSCT) scans of 120 individuals (47 males aged 23-88 years old, 73 females aged 20-85 years old) with recorded data on the age, sex, weight, and stature. The authors found that when studying males and females with a BMI>25, all methods produced results that underestimated body mass, and they discovered that the underestimation of body mass increases according to BMI among females (Lorkiewicz-Muszyńska et al. 2013: 405.e4).

Elliott and colleagues' 2015 study titled "Estimating Body Mass from Skeletal Material: New Predictive Equations and Methodological Insights from Analyses of a Known-Mass Sample of Humans" also found that BME techniques are problematic for identifying bodily extremes such as emaciation and obesity. The authors derived new regression equations by using three common inverse calibration methods: least square, reduced major axis, and major axis regression (Elliott et al. 2015: 4), and these equations were used to test 12 cranial and 24 postcranial variables associated with body mass. The authors tested the accuracy of the new BME equations by applying them on the CT data of 253 deceased modern humans with pre-recorded data (sex, age, body mass, and stature). When compared to previous BME studies, the authors found that least square regression results yielded lower rates of error for orbital area, orbital height, and femoral head breadth, whereas the bi-porionic breadth produced higher rates of error compared to results from previous research (Elliott et al. 2015: 14-15). While Elliott and colleagues' improved BME regression equations demonstrated a noticeable increase in accuracy, this study determined that BME equations still lacked the precision required to identify extreme body states such as obesity and emaciation from skeletal populations.

Body Mass Estimation in Bioarchaeology

Body mass estimation is often used in bioarchaeological research to analyze the range and variation of body size among early hominins (Holliday 2012: S338; Grabowski et al. 2015: 75; Walker et al. 2017: 1). Body size is correlated with biological, ecological, and behavioral characteristics; moreover, studies on body size in early hominins can provide further insight on changes in brain size, energetic requirements, diet quality, habitat, home range size, foraging strategies, metabolic rate, thermoregulation, and social behavior (Hartwig-Schierer 1993: 17; McHenry 1994: 77-78; Wood and Collard 1999: 67; Hens et al. 1999: 767; Robson and Wood 2008: 401; Bernstein 2010: 47; Holliday 2012: S338; Squyres and Ruff 2015: 18; Grabowski et al. 2015: 75; Will et al. 2017: 2; Walker et al. 2017: 1). Body morphology is extremely varied among living human populations, and researchers have utilized BME techniques in order to determine the extent of variation in body size among early hominins (Ruff 2002: 211; Gallagher 2013: 552).

Estimation of body mass in fossil hominins reveals significant differences in body size and sexual dimorphism between Australopithecines and early *Homo* (Leonard and Robertson 1997: 266; McHenry and Coffing 2000: 128; Leonard 2010: S289; Holliday 2012: S340; Anton et al. 2014: 1236828; Will et al. 2017: 17). Table 5.1 lists the average body masses for early hominins as estimated by Squyres and Ruff (2010), Ruff (2010), McHenry (1992), Jungers (1988), and McHenry (1988). The available post-cranial remains for *Australopithecus* can be categorized into two size groupings, and it is hypothesized that the large size grouping is representative of male australopiths while the smaller size grouping represents the females (McHenry 1994: 78). While differences in body size between male and female australopiths is discernible, BME of *Homo erectus* indicates a reduction of sexual dimorphism due to an estimated increase in female body size (McHenry 1994: 78; Aiello and Wells 2002: 324 Robson and Wood 2008: 410). *Homo erectus* males are estimated to have weighed an average of 63kg while females weighed 52kg (Leonard and Robertson 1997: 275). As mentioned in chapter 3, it is theorized that this increase in hominin female body size is in response to the increased energetic demands of pregnancy and childbirth (Aiello and Wells 2002: 324; Leonard et al. 2003: 13). The average body size of *Homo erectus* is comparable to those of modern humans, as the averages for *Homo sapiens* are 65kg for males and 54kg for females (Leonard and Robertson 1997: 275; Robson and Wood 2008: 416; Leonard 2010: S289; Anton et al. 2014: 1236828).

Table 5.1. Average body mass estimates in kilograms for early hominins (Squyres and Ruff 2015: 206)

Taxon	Squyres and Ruff 2010	Ruff 2010	McHenry 1992	Jungers 1988	McHenry 1988
Au. afarensis	46.1	37.8	37	51	51
Au. africanus	38.4	34.3	35.5	46	46
Early *Homo*	53.6	58.3	___	___	59

Estimation of body mass is significant in analyzing evolutionary changes in brain size (McHenry and Coffing 2000: 137). Between 4.0-2.0 mya, Australopithecine brain sizes reached an average of 400-500 cubic centimeters, which is similar to the brain sizes of modern apes (Leonard 2002: 108; Leonard et al. 2003: 9; Leonard 2010: S289). Brain size in *Homo habilis* is estimated to average 600 cubic centimeters between 2.4-1.6 mya, while early *Homo erectus* had an estimated brain size averaging 800-900 cubic centimeters (Leonard 2002: 108; Leonard et al. 2003: 9). At approximately 0.1 mya, brain sizes among modern humans reached an average of 1,350 cubic centimeters (Foley and Lee 1991: 225; Leonard 2002: 108). Encephalization is associated with an increase in energetic demands, and body mass has been utilized to estimate resting metabolic rate (RMR) and its variation among early hominin species. RMR is the base amount of energy required to maintain the biological functions of an inactive organism while under thermoneutral conditions (Leonard and Robertson 1997: 268). Using the equation RMR(kcal/day) = 70(Body Weight)$^{0.75}$, Australopithecines are estimated in requiring an average of 850-1,000 kcal/day for females and 1,100-1,300kcal/day for males (Leonard and Robertson 1997: 275). The energetic demands of *Homo habilis* is similar to *Australopithecus*, with 931kcal/day for females and 1,348kcal/day for males (Leonard and Robertson 1997: 268). *Homo erectus* and *Homo sapiens* have increased RMRs with an estimate of 1,300-1,400kcal/day for females and 1,500-1,600kcal/day for males (Leonard and Robertson 1997: 275).

The increase in body and brain sizes among early hominins indicates an increase in energetic demands, which are fulfilled by improvements in dietary intake and nutrition (Leonard and Robertson 1994: 83; Aiello and Wells 2002: 325; Leonard et al. 2003: 6; Holliday 2012: S341). Diet quality (DQ) is calculated as DQ = 3.5(a)+2(r)+s, where (a) represents the percentage of animal material consumed, (r) represents percentage of reproductive plant parts consumed, and (s) represents the percentage of structural plant parts consumed (Leonard and Robertson 1997: 267). DQ ranges between 100 and 350, where a minimum DQ of 100 indicates a strictly herbivorous diet while a maximum DQ of 350 indicates a carnivorous diet (Leonard and Robertson 1997: 267). The effect that dietary quality has on body size can be observed among extant apes. Gorillas and orangutans consume large volumes of resources that are accessible but low in nutritional value, such as leaves and bark (Leonard et al. 2003: 8; Milton 2003: 3888S). Modern humans have a higher quality diet than requires the consumption of a smaller amount of food compared to extant apes; however, the accessibility of nutrient dense food resources among modernized populations has led to the increase of excessive body weight among humans (Bindon and Baker 1997: 202).

BME studies are also significant in reconstructing the palaeoecology of early hominins in order to understand how environmental changes impacts the selection of particular adaptive traits (Potts 1998: 105; Hens et al. 1999: 768; Walker et al. 2017: 2). The savanna hypothesis proposes that the eastern and southern regions of Africa experienced a reduction of forested habitats while savanna grasslands spread due to climate shifts between 2.5-1.5 mya (Leonard and Robertson 1997: 276; Potts 1998: 106). The shift from enclosed forested environments to open savanna grasslands would have provided early *Homo* with the opportunity to alter their subsistence strategies and exploit new calorically-dense animal and plant resources (Leonard and Robertson 1997: 266; Katzmarzyk and Leonard 1998: 491; Aiello and Wells 2002: 326). Ecological changes impacted hominin body sizes, resource distribution, and ranging patterns as depicted in Figure 5.2. In a woodland/savanna environment, nutrient dense foods such as ripened fruits fluctuate with the changing seasons (Milton 2003: 390S). Shifts in climate would have impacted the abundance and distribution of resources, and researchers have proposed that early hominins met their increased energetic demands by consuming an improved diet of high quality resources such as meat and bone marrow (Leonard and Robertson 1997: 276; Cachel and Harris 1998: 115; Leonard et al. 2003: 9; Navarrete et al. 2011: 92; Holliday 2012: S341; Pontzer 2012: S347). The consumption of animal materials among ancestral humans is also evidenced by changes in other morphological features, such as the reduction of the masticatory apparatus in *Homo erectus* as diet shifted from tough, fibrous plant materials to cooked animal resources (Leonard and Robertson 1997: 278; Aiello and Wells 2002: 326).

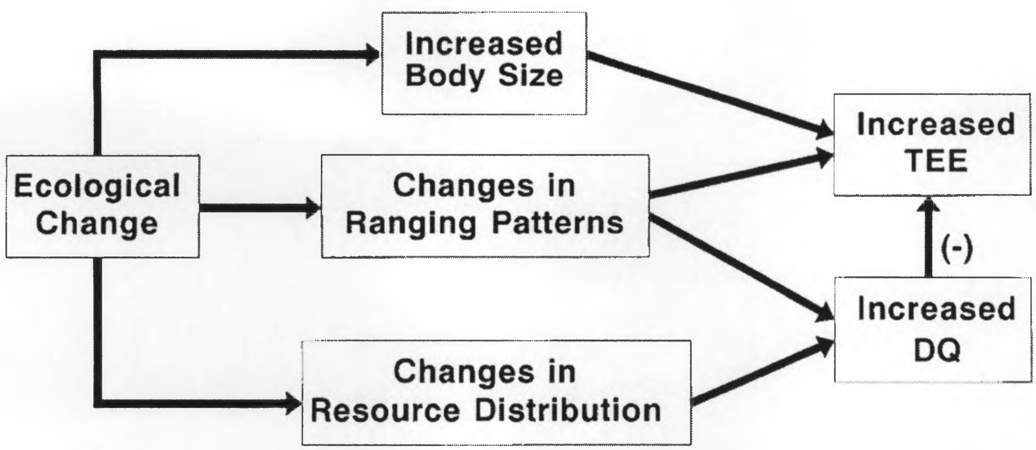


Figure 5.2. Diagram demonstrating the hypothesized interactions between ecology, body size, dietary quality, and total energy expenditure (TEE) among early hominins (Leonard and Robertson 1997: 278)

Shifts in hominin palaeoecology would have impacted resources distribution. Consequently, the larger body size and higher energetic needs of early *Homo* would have also resulted in an increased home-range size. Home-range size is an established function of body size among mammals (Harestad and Bunnell 1979: 399; Holliday 2012: S341). Researchers calculate home-range size among omnivores with the equation $H = 0.05W^{0.92}$, where H indicates home-range in hectares and W indicates body weight in grams (Harestad and Bunnell 1979: 390; McHenry 1994: 83). The shift in home-range sizes between *Australopithecus* and *Homo* is demonstrated in Table 5.2. As the habitat of early *Homo* became more open with patchily distributed resources, it is hypothesized that early *Homo* expanded their home-ranges and practiced hunting-and-gathering strategies in an attempt to acquire high-quality food resources (Leonard and Robertson 1997: 278; Cachel and Harris 1998: 114-115). Their increased body size and improved diet quality would have allowed them to range more widely compared to later Australopithecines (Holliday 2012: S341; Pontzer 2012: S354). It is hypothesized that the increase in body size and home-ranges allowed *Homo* to migrate out of Africa (Cachel and Harris 1998: 121; Anton and Swisher 2004: 284; Holliday 2012: S341).

Table 5.2. Estimated body weight (kg) and home-range size (ha) of fossil hominins. Body weights were estimated according to McHenry 1992 and 1994. Home-range calculated as logHR = 1.36(logWeight)+0.009(Diet Quality)-2.01. HR-Ape uses modern ape DQ of 164, while HR-Human uses modern tropical forager DQ of 252 (Anton and Swisher 2004: 288)

Species	Average Weight (kg)	HR-Ape (ha)	HR-Human (ha)
Au. afarensis	37.0	40	247
Au. africanus	35.5	38	234
Au. robustus	36.1	39	239
Au. boisei	44.3	51	316
H. habilis	41.6	47	290
H. erectus	57.7	73	452
Large Koobi Fora early *Homo*	46.0	53	331
Dmanisi 2021	46.0	53	331
African *H. erectus* & Dmanisi	54.2	66	413
African *H. erectus,* Dmanisi, & Early Koobi Fora *Homo*	51.0	61	380
H. sapiens	59.5	76	471

Body mass estimation has also been utilized by forensic anthropologists in order to aid in the personal identification of modern humans, especially from juvenile remains (Robbins et al. 2010: 146). An influential BME study on juvenile fossil remains focuses on the specimen KNM-WT 15000, a 1.47 ma *Homo ergaster/erectus* individual from West Turkana, Kenya (Ruff and Burgess 2015: 74). Also referred to as the "Nariokotome Boy", KNM-WT 15000 is the most complete early hominin skeleton discovered to date (Ruff and Burgess 2015: 74). Comparative studies utilizing KNM-WT 15000 must acknowledge its juvenile status by restricting comparisons to individuals of similar developmental status or by estimating KNM-WT 15000's growth into adulthood (Ruff and Burgess 2015: 74). Ruff and Burgess focus on the potential growth of KNM-WT 15000 due to the lack of comparable juvenile fossil remains. KNM-WT 15000 was originally aged between 11 and 12 years old, and BME from distal femoral metaphyseal and head breadths predicted a weight of 48kg at death with a peak of 68kg into adulthood (Ruff 2007: 706). However, Ruff and Burgess hypothesize that KNM-WT 15000 likely followed the growth pattern of modern chimpanzees instead of humans (Ruff and Burgess 2015: 76). Using modern African ape reference samples would therefore yield the minimum estimates of growth in KNM-WT 15000. Further analysis on the degree of epiphyseal fusion is indicative of a younger age-at-death than previously assumed, around eight years old (Ruff and Burgess 2015: 76). Using Grine's [body mass in kg = 2.268(femoral head breadth in mm)-36.5] and Ruff's [body mass in kg = (2.741(femoral head breadth in mm)-54.9)(0.9)] BME equations, Ruff and Burgess produced heavier weight estimates between 50-53kg at age-of-death with a predicted adulthood estimate of 80.1-82.6kg (Ruff and Burgess 2015: 75). While these estimates are likely to have varied based on ecological influences experienced by KNM-WT 15000, Ruff and Burgess' analysis provides further insight on the potential growth of the juvenile *Homo erectus* specimen.

Body Size and Bio-cultural Environment

While BME is commonly utilized in bioarchaeological studies as a measure of body size, another variable used by researchers is stature (Hens et al. 1999: 768). Stature is observed to be affected by an individual's bio-cultural environment, which refers to the social, economic, and health conditions in which a population lived (Schweich and Knüsel 2003: 367). Skeletal growth occurs at the epiphyses; however, growth is interrupted when the body is exposed to malnutrition or disease, as energetic resources are prioritized towards repairing pathological damage or maintaining basic physiological functions in order to ensure survival (Schweich and Knüsel 2003: 368). The relationship between bio-cultural environment and human body size is analyzed in Schweich and

Knüsel's study on body mass and stature among medieval skeletal populations. The authors analyzed five medieval skeletal populations (total n = 302) from the sites of Chichester in West Sussex and Fishergate in York (Table 5.3.). Fishergate is categorized into two periods, early (1050-1150 BCE) and late (1200-1350 BCE) Fishergate (Schweich and Knüsel 2003: 368). The Fishergate site from the early period was used by the lay population of York as a parish cemetery, while the three later periods were used as the burial grounds for the noble community of the Gilbertine priory (Schweich and Knüsel 2003: 368). The Chichester site functioned as a leprosarium that segregated individuals who suffered from leprosy from the rest of the populations (Schweich and Knüsel 2003: 371). The authors selected these sites based on their well-documented bio-cultural backgrounds, their large sample sizes, and their accessibility (Schweich and Knüsel 2003: 368).

Table 5.3. Information on the site location, type, period, and sample (Schweich and Knüsel 2003: 373)

Site	Type	Period	*N*
Fishergate, York	Early period, St. Andrew's Church	11^{th}-12^{th} century AD	33
	Late period, intramural cemetery, Gilbertine priory	12^{th}-14^{th} century AD	69
	Late period, eastern cemetery, Gilbertine priory	12^{th}-14^{th} century AD	39
	Late period, southern cemetery, Gilbertine priory	12^{th}-14^{th} century AD	33
Chichester, West Sussex	Urban hospital and leprosarium cemetery	12^{th}-18^{th} century AD	128
Total			302

Body weight was estimated using Ruff's method, where Weight = -85.8 + 3.383(femoral head diameter), and the standard error of estimation (SEE) is ±14.7kg (Schweich and Knüsel 2003: 371). Stature was estimated using Trotter's method, where Stature = 61.41 + 2.38(femur length) and SEE is ±2.99cm (Schweich and Knüsel 2003:

371). The results of Schweich and Knüsel's analysis are illustrated in Figure 5.3. The highest averages in stature (172.3cm) and weight (73.0kg) belong to the earliest Fishergate site, while the lowest averages in stature (168.1cm) and weight (69.7kg) are present in the Chichester site. The data collected on the Chichester site functioned to demonstrate the relationship between small body sizes and the poor health conditions and socioeconomic status of the leprosarium individuals. The reduction in stature from the early to late Fishergate sites is unexpected, as the increase of social status of the Gilbertine priory should have been related to an increase in stature. The decrease in stature is hypothesized to be the result nutritional stress experienced prior to the bubonic plague (Schweich and Knüsel 2003: 374-375). However, the later Fishergate samples experienced an increase in weight correlated with improvements in bio-cultural conditions and heightened socioeconomic status. The conflicting implications of stature and weight among the Fishergate samples may indicate the bio-cultural environment at different life-course periods (Schweich and Knüsel 2003: 376).

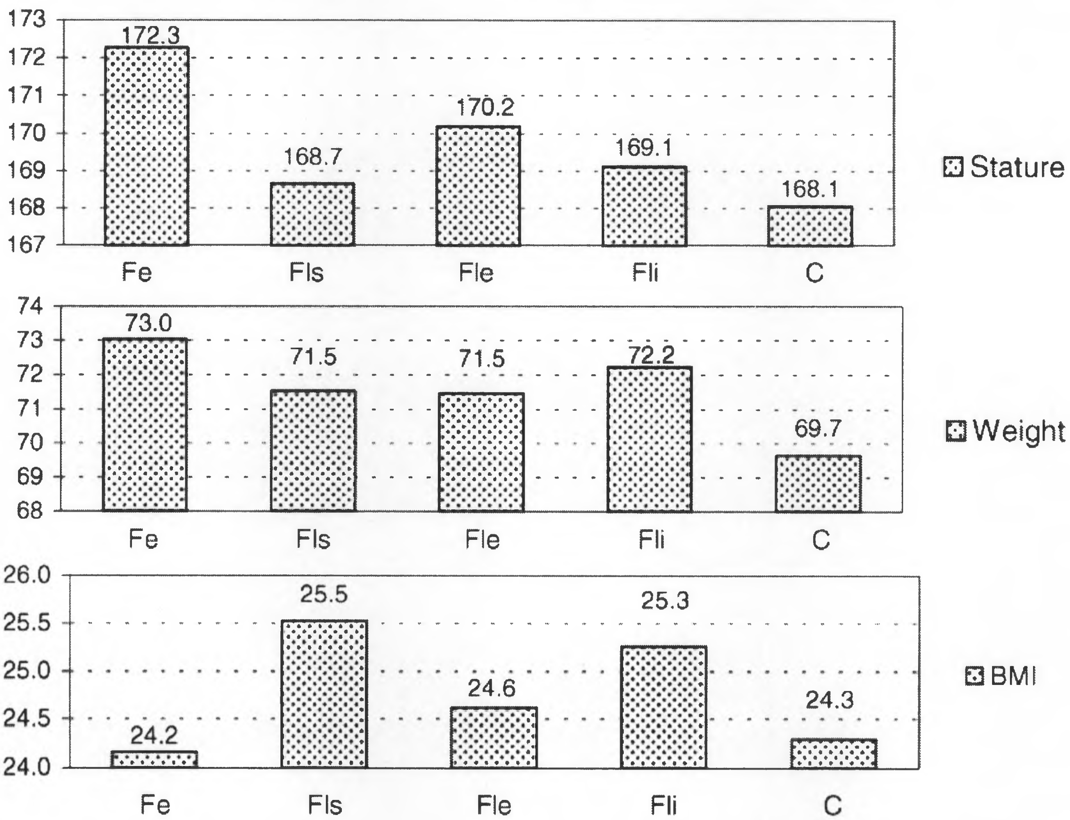


Figure 5.3. Stature (cm), weight (kg), and BMI (kg/m^2) for Fishergate early period (Fe), Fishergate late period southern cemetery (Fls), Fishergate late period eastern cemetery (Fle), Fishergate late period intramural cemetery (Fli), and the Chichester site (C) (Schweich and Knüsel 2003: 373)

Body mass estimation is commonly used in analyzing the variation in body sizes between population groups. However, Faccia and colleagues utilized BME techniques in order to compare the body size of a large-bodied middle Holocene Kitoi individual with contemporaneous burial samples. The authors analyzed the burials located at the Shamanka II site located in the Lake Baikal region in Siberia, Russia. Shamanka II is a burial site that was utilized from approximately 7500-6500 BP by the Kitoi, a foraging forest Neolithic population (Faccia et al. 2016: 68). Kitoi burials at this location are varied in position, treatment, and grave goods, which indicates that they were likely a socially stratified foraging community (Faccia et al. 2016: 68). A major point of interest is the analysis of Burial 76.1. Faccia and colleagues assert that this burial belonged to a Kitoi individual of the lowest status based on the skeletal positioning and burial simplicity. High status individuals were buried in a supine and fully extended position, and the burials would also be decorated with red ochre and contain artifacts such as stone points and modified antler (Schweich and Knüsel 2003: 69). In contrast, Burial 76.1 was unadorned and the body laid in a supine and semi-flexed position (Schweich and Knusel 2003: 69).

Site	Individual	Age category	Stature (cm)						Body mass (kg)
			Femur (a)	Tibia (a)	Femur (b)	Tibia (b)	Femur (c)	Tibia (c)	
Lokomotiv	12-1	Young adult	153.01	155.25	159.40	161.36	161.35	164.84	48.58
Lokomotiv	14-1	Young adult	155.19	154.32	161.59	160.46	163.32	163.99	47.82
Lokomotiv	20-1	Young adult	158.31	159.26	164.02	164.33	166.16	168.52	50.73
Lokomotiv	21-1	Old adult	152.47	*	159.47	*	160.85	*	58.18
Lokomotiv	25-2	Young adult	153.69	156.64	159.95	162.43	161.96	166.12	43.48
Lokomotiv	36-1	Young adult	153.55	151.22	160.31	158.04	161.84	161.16	43.03
Lokomotiv	38-1	Old adult	150.56	155.40	157.98	161.31	159.12	164.98	51.80
Lokomotiv-R	13-3	Young adult	154.23	154.01	160.84	160.22	162.46	163.71	49.92
Lokomotiv-R	13-4	Young adult	149.34	153.55	156.46	160.07	158.01	163.29	46.53
Shamanka II	76-1	Middle adult	157.50	157.10	163.39	162.78	165.42	166.54	72.46

Figure 5.4. Comparison of 76.1 with Kitoi males from the sites of Lokomotiv and Lokomotiv-Raisovet. Stature and BME were estimated using Ruff et al. 2010 (a), Trotter and Gleser 1958 (b), and Hasegawa et al. 2009 (c) (Faccia et al. 2016: 73)

The authors utilized measurements from the superior-inferior femoral head diameter, maximum femur length, and maximum tibial length in order to estimate the body mass and stature of 10 adult Kitoi remains (Faccia et al. 2016: 69). Faccia and colleagues estimated 76.1 as a middle-aged adult (35-49 years) male who stood between 1.57 and 1.67 meters tall and weighed an estimated 72.46kg (Faccia et al. 2016: 73). When compared to the contemporaneous Kitoi males found at the site, specimen 76.1 was similar in height but noticeably deviated from the average body weight of 48.90kg (Figure 5.4). Individual 76.1 was also diagnosed with diffuse idiopathic skeletal hyperostosis (DISH; see chapter 6), which is associated with obesity and rarely observed among foraging populations (Faccia et al. 2016: 74, 76). Additional analysis in dietary stable isotopes and muscular robusticity indicates that 76.1 had similar activity and dietary patterns compared to the other Kitoi samples (Faccia et al. 2016: 74). Faccia and colleagues propose that 76.1 may have experienced stress *in utero* due to maternal malnutrition; which is likely if 76.1 acquired his low status from his family (Faccia et al. 2016: 76). This study focuses on the abnormal body size of the 76.1 Kitoi individual with the aim of determining the difference in life-history compared to the contemporaneous Kitoi samples.

Summary

These previous BME studies illustrate the problematic issues that are encountered in attempted to identify BMI extremes such as obesity and emaciation from skeletal remains. While these methods provide a possibility to estimate body mass from skeletal remains, multiple regression equations have little predictability power for estimating excess body weight (Moore 2009: 107). Although these multiple regression equations using cross-sectional geometry alone are not useful predictive models in estimating body mass, they can still be applied to archaeological samples when also analyzing other indicators of obesity. Numerous studies have attempted to reconstruct the biological, ecological, and behavioral characteristics of fossil hominins through BME methods. Most of these studies focus on the variation of body size between population groups, but BME is also useful in identifying individual instances of abnormal levels of body mass within a population. The following chapter will discuss important associated skeletal pathologies that researchers may analyze alongside with BME techniques in order to gain a better perspective on obesity in archaeology.

Chapter 6: Associated Skeletal Pathologies

As explained in the previous chapter, attempts to directly identify the corporeal condition of obesity through body mass estimation techniques will result in issues of accuracy. However, scholars may indirectly analyze obesity by studying skeletal pathologies that are clinically associated with obesity. Obesity is often associated with diseases such as diabetes mellitus type II, cardiovascular diseases, and reproductive cancers (Lieberman 2013: 287); however, these conditions do not leave observable lesions on the bone that can be identified from skeletal remains in the archaeological record. Instead, an archaeological analysis of obesity and excess body weight will focus on an extensive analysis of three specific skeletal pathologies: diffuse idiopathic skeletal hyperostosis (DISH), hyperostosis frontalis interna (HFI), and metabolic arthritis (gout). Identifying the presence and high frequencies of these skeletal conditions will reveal beneficial information regarding the potential origins and natural histories of these pathologies and their association with obesity. Additionally, paleopathology research will provide further insight on the various cultural, biological, and environmental factors that may have aided in the development of obesity and excess body fatness in humans. The following pathology sections will provide a clinical description of the condition, a description of its association with obesity, and relevant archaeological case studies.

Diffuse Idiopathic Skeletal Hyperostosis

A pathological condition that is often associated with obesity is diffuse idiopathic skeletal hyperostosis (DISH). DISH was first described by Forestier and Rotes-Querol in 1950 (Forestier and Rotes-Querol 1950: 325; Mazieres 2013: 466; Pillai and Littlejohn 2014: 116; Pulcherio et al. 2014: 162). While originally termed “Forestier’s disease”, the name changed in order to indicate that this condition consists of a range in skeletal abnormalities instead of being a single isolated spinal disease (Verlaan et al. 2007: 1132). An issue regarding DISH studies is the variance in criteria used by researchers in diagnosing DISH in the skeleton (Faccia et al. 2016: 67), and this can be observed in the differences in diagnostic specificity as developed by Resnick and Niwayama, Julkunen, and Utsinger in Table 6.1 (Yunoki et al. 2016: 510). However, emphasis is generally placed on identifying the major distinctive characteristics of DISH rather than on minor criteria. An example would be prioritizing the presence of ossifying excrescences on the right thoracic vertebrae rather than focusing on the narrowing vertebral disk spaces and the appearance of the apophyseal joints between each vertebral body (Faccia et al. 2016: 69).

Table 6.1. Variation in DISH criteria as described by Resnick and Niwayama, Julkunen, and Utsinger (adapted from Yunoki et al. 2016: 510)

Resnick and Niwayama 1976	1. Flowing ossification along anterolateral aspect of at least four contiguous vertebral bodies 2. Relative preservation of intervertebral disc height in the involved segment 3. Absence of apophyseal joint bony ankyloses and sacroiliac joint erosion
Julkunen et al. 1975	Same criteria as Resnick and Niwayama, but includes the bridges connecting two vertebral bodies in at least two sites on the thoracic spine
Utsinger et al. 1976	Definite DISH: Bridging of four contiguous vertebral bodies primarily in thoracolumbar spine; minimal intervertebral disc disease, no facet joint ankyloses
	Probable DISH: Bridging of two contiguous vertebral bodies plus bilateral patellar tufting, heel spurring, and olecranon (bony tip near end of ulna) tufting
	Possible DISH: Two vertebrae joining in absence of extraspinal enthesophytes (abnormal bony projections at tendon or ligament attachment) or symmetrical extraspinal enthesophytes in the absence of spinal involvement

A description of DISH that is commonly referred to is provided by Rogers and Waldron, who diagnose DISH as excessive bone growth (hyperostosis) ankylosing of the spinal column, including the accumulation of calcium (calcification) or ossification of tendon and ligament attachments (entheses) to bone in extraspinal regions of the body (Rogers and Waldron 2001: 357). Early research on spinal pathologies often confused DISH with other conditions such as ankylosing spondylitis (AS), as both DISH and AS produce excessive spinal bone proliferation (Rogers et al. 1985: 118; Saleem and Hawass 2014: 3311). However, DISH ossification of the vertebral bodies produces a distinct morphological appearance which is often described as melting candle wax on the right side of the thoracic spinal column (Lazer 2009: 153, 201). The thoracic region of the spine is the primary location for DISH to emerge, followed by the lumbar and cervical regions (Pulcherio et al. 2014: 162). While DISH identification generally focuses on analysis of the spinal column, the onset of DISH may affect extraspinal regions (Faccia et al. 2016: 69). Additionally, vertebrae may not preserve well when compared to long bones or tarsals in archaeological contexts, and the absence of archaeological vertebrae could reduce the estimated DISH prevalence among past populations (Faccia et al. 2016: 69).

Table 6.2. Morphological characteristics of DISH (Faccia et al. 2016: 70)

Age of onset	Middle/old adult (40+ years of age)
Sex bias	Male
Vertebral appearance	Ossification of the anterior longitudinal ligament and connective tissue; left side unaffected in region of descending aorta (thoracic); flowing "candle-wax" appearance; apophyseal joints unaffected; involvement of 3-4 contiguous vertebrae; thoracic predisposition; possible cervical/lumbar involvement
Sacroiliac appearance	Joint space maintained; ossification of capsule possible
Extraspinal pattern	Calcification/ossification of ligaments and entheses; "Whiskering" appearance; peripheral osteophytes possible; possible involvement of posterior calcaneus, superior patella, and ulnar; symmetric olecranon

This pathology is prevalent among affluent societies, yet it is largely undiagnosed due to its asymptomatic nature (Tonelli 2011: 52; Pulcherio et al. 2014: 162). The mild symptoms that result from DISH are dependent on the location of the abnormal bone growths. Excessive bone growths located on the cervical region of the spine will result in breathing (progressive airway obstruction and obstructive sleep apnea) and swallowing (dysphagia) problems (Verlaan et al. 2007: 1130). The most commonly experienced symptoms are mild back pain and stiffness, which occurs from DISH affliction in the thoracic and lumbar regions of the spinal column (Verlaan et al. 2007: 1130; Fornaciari et al. 2009: 376). Although DISH is often regarded as producing no or mild symptoms, it can significantly increase morbidity due to the possible compression of the spinal cord, which could lead to a range of nervous system disorders and sudden paraplegia (Rogers and Waldron 2001: 359).

Palaeopathological studies provide evidence that DISH existed among past populations (Verlaan et al. 2007: 1130; Faccia et al. 2016: 66). However, the etiology of DISH is unknown. Authors can only speculate on the environmental, biological, and cultural factors that may promote the emergence of DISH. Microtrauma to the bone may trigger the emergence of DISH as a result of the subsequent entheseal ossifications that occur in response to the damage (Faccia et al. 2016; 67). Individuals may also be prone to DISH based on their genetic background, as variance in enzyme expression could result in greater bone formation among the carriers of this gene (Faccia et al. 2016: 67). These individuals are termed "bone-formers" and produce excessive bone deposition as a response to stress (Quintelier et al. 2014: 205). Additionally, it has also been theorized that DISH could be a response to correcting altered body stability. Ossification of the spinal column would aid the body in adapting to excess weight while also restricting movement due to the fused vertebral joints (Moore and Schaefer 2011: 1116). This explanation strengthens the association between DISH and obesity by describing DISH as a skeletal reaction towards the maladaptation of excess weight on the human skeletal frame.

Prevalence in DISH is also dependent on geographic location and categorized population groups (Rogers et al. 2001: 358). Contemporary demographic studies revealed considerable disparities in DISH affliction between racial groups. Korean groups exhibited a DISH prevalence of 2.9% while Caucasian groups ranged up to 10.0% in prevalence; additionally, the male to female ratio in DISH diagnosis is 2:1 (Verlaan et al. 2007: 1130). This contrast in DISH prevalence could be influenced by genetic expression and dietary intake. The theory for genetic predisposition of DISH is further supported by the hereditary nature of DISH expression among multiple members of a family group (Faccia et al. 2016: 67). However, the genetic background of DISH is unknown and requires further analysis.

Aside from genetic explanation, the high prevalence of DISH among Western populations may be influenced by a calorific diet. A high calorie diet is considered to play a significant role in the presence of DISH (Faccia et al. 2016: 67). As a result, this creates an association between DISH and obesity, as the latter is commonly defined as an imbalance of energy created by the overconsumption of calories with a lack of physical activity. The link between DISH and obesity was also observed in Forestier and Rotes-Querol's early study which indicated that six of the nine (67%) affected males were clinically obese (Forestier and Rotes-Querol 1950: 322; Pillai and Littlejohn 2014: 116). The relationship between DISH and dietary intake thus explains the high rates of DISH prevalence among Caucasian groups consuming a Western diet high in animal proteins, while Korean groups generally consumed a traditional diet high in plant and marine proteins.

The relationship between DISH and a calorific diet is strengthened by carbon and nitrogen isotope analysis. This method analyzes the stable isotopes in bone collagen; moreover, the $\delta^{13}C$ and $\delta^{15}N$ levels in skeletal remains can provide information on the trends in the consumption of terrestrial plants, animal proteins, and marine proteins (Quintelier et al. 2014: 208). Analysis of $\delta^{13}C$ levels distinguishes between the consumption of marine C_3 and terrestrial C_3 and C_4 plants, while $\delta^{15}N$ indicates the trophic level of an individual (Kelly 2000: 4). High $\delta^{15}N$ levels indicate a diet rich in meat and are generally observed among carnivorous animals (Fornaciari et al. 2009: 376). Individuals with DISH will have elevated $\delta^{15}N$ levels, which links the pathology with a diet heavy in animal and marine proteins. This results in the assumption that DISH is a condition that mainly affected elite individuals living a sedentary lifestyle with access to an abundance of high-calorie foods. While studies attempt to strengthen the associations between DISH and dietary intake through stable isotope analysis, the presence of DISH should not be the only indicating factor in determining the status or occupation of an individual (Faccia et al. 2016: 66). Moreover, studies of DISH in less socially stratified societies in prehistoric maritime foraging groups in South America and Japan contradicts the argument that DISH is indicative of social status (Faccia et al. 2016: 67).

Research on DISH also indicates that the presence and severity of this condition is strongly correlated with advancing age (Mazieres 2013: 468). Older males have a greater risk in developing DISH (Verlaan et al. 2007: 1129; Lazer 2009: 153), and contemporary studies provide data on the absence of DISH among individuals under 40 years of age (Rogers et al. 2011: 117). Some researchers have advocated to reclassify DISH as a condition reflective of the natural aging process rather than labeling it a disease (Lazer 2009: 201-202). Theories relating DISH to old age create the assumption that DISH should therefore not be present in archaeological contexts, as scholars argue that earlier populations would have had shorter lifespans that prevented the expression of this condition (Rogers et al. 2011: 117). However, this explanation is contradicted by the presence of DISH archaeological collections, such as the two cases in a Pompeiian skeletal collection. While low in frequency, DISH presence in remains dating to the AD 79 eruption of Mount Vesuvius indicates that humans lived long enough to express these skeletal changes (Lazer 2009: 153, 203).

DISH and Monastic Lifestyles

Because DISH is commonly associated with elite status, research on this condition centers on its presence in the remains of individuals with known status, specifically in the remains within elite and monastic burials. A notable study identifying the association between DISH and status was conducted by Rogers and Waldron in remains from Merton Priory burials. The researchers analyzed skeletal remains that were uncovered in the lay and church cemeteries located at the Wells Cathedral and the Royal Mint in London. Excavation of the Wells Cathedral provided the authors with 287 well preserved skeletons from three separate cemeteries: the general lay cemetery, the thirteenth century lady chapel, and the sixteenth century Stillington's chapel. The skeletal remains located at the Wells Cathedral indicated a range of DISH affliction (Table 6.3); however, these results proved not to be statistically significant.

Table 6.3. Wells Cathedral DISH prevalence (Rogers and Waldron 2001: 360)

Site	Number of males	DISH affected	Prevalence (%)
Lay cemetery	93	6	6.5
Lady Chapel	15	2	13.3
Stilington's chapel	13	3	23.1

The Royal Mint site was originally a Black Death plague pit, but the Abbey of St. Mary Graces was built over the original site in 1350 (Rogers and Waldron 2001: 362). Similar to the Wells Cathedral site, the Abbey contains lay, church, and chapel cemeteries. The Royal Mint site revealed significant variance of DISH affliction between high-status and low-status burials (Table 6.4), which supports the assertion that DISH is influenced by lifestyle factors. However, an issue with this study is that the authors could not discern between religious clergy individuals and wealthy lay benefactors. It is assumed that individuals buried within the chapel cemeteries were considered to have a higher social status compared to the other cemeteries which would have held the general population (Rogers and Waldron 2001: 360). When combing the data from both sites, the authors discovered that the high DISH frequencies are significant and not coincidental (Rogers and Waldron 2001: 361).

Table 6.4. Old Royal Mint site DISH prevalence (Rogers and Waldron 2001: 360)

Site	Number of males	DISH affected	Prevalence (%)
Lay cemetery	99	0	0
Church and chapels	52	6	11.5

The authors also refer to textual documentation that supports the link between DISH and the monastic lifestyle. These documents refer to the calorific diets consumed by the church monks, and these texts also suggest that the monks would actively seek loopholes regarding their restrictive dietary guidelines implemented by the church. The authors describe how monks in a thirteenth century French monastery were limited to eating only hunted game meat, and they overcame this restriction by sneaking dogs into the monastery to chase and effectively "hunt" the nearby farm pigs (Rogers and Waldron 2001: 362). These actions explain why monks were stereotyped as gluttonous individuals by people outside of the church; however, gluttony is a term that is used to describe excessively greedy behavior and not physical appearance (Hill 2011: 11). While the authors provide no description of the possible physical attributes of the monks, obesity may be linked to these monks by analyzing the high calorie diets of the monks. The monks were allowed an average of 4,870-6,207 calories depending on the religious season, which may put them at risk of developing obesity and diabetes mellitus type II (Rogers and Waldron 2001: 362). Therefore, the high frequency of DISH among these individuals provides a strong basis for the association between DISH, dietary intake, and potential obesity among the monks.

Another study that analyzes the relationship between DISH and the monastic lifestyle is Quintelier and colleagues' isotope analysis of skeletal remains from post-Medieval (16^{th}-18^{th} century) friary burial sites in the province of Alast in East Flanders, Belgium. The burial sites included three locations: the church, the cloister alley, and the cloister garth (Figure 6.1). Similar to Roger and Waldron's study, the researchers were unable to differentiate between the remains of monastic friars and average lay people because the burials within these cemeteries were of mixed sex and social status. The researchers utilized archival evidence in order to establish that friars are customarily buried in the cloister alley while the wealthy lay people were generally buried in the church cemetery (Quintelier et al. 2014: 206).

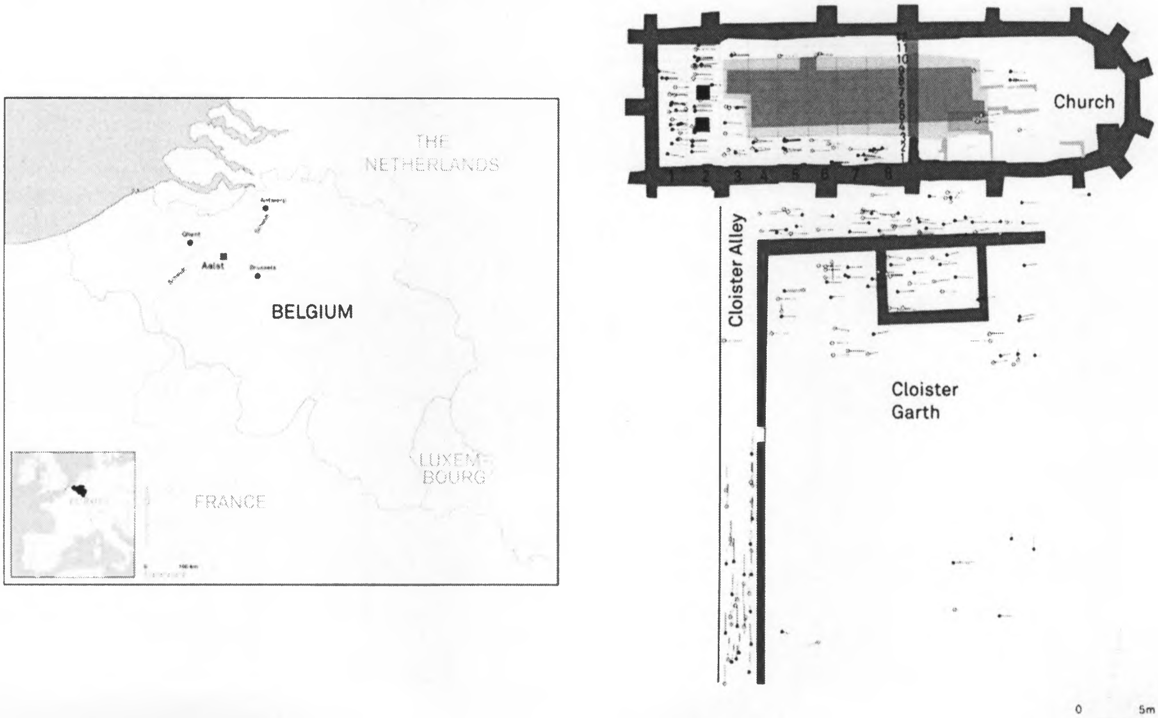


Figure 6.1. A map of Alast, Belgium [left] and a map of the excavated building of the Carmelite friary at Alast [right] (Quintelier et al. 2014: 205-206)

The skeletal sample from the three burial locations consisted of 238 skeletal individuals, and 39 of the skeletons satisfied the authors' criteria for DISH or probable DISH (Table 6.1). This study indicated that the pathology was higher in frequency among the males buried within the church and cloister alley cemeteries compared to those buried in the cloister garth, and the individuals buried in the high-frequency areas were most likely monks or wealthy benefactors (Quintelier et al. 2014: 211). Additionally, the samples resulted in high carbon and nitrogen isotope values, which are indicative of a diverse diet of animal proteins that is assumed to be an indicator of wealth and social status (Quintelier et al. 2014: 211). However, these results were not statistically significant. As a result, the authors' inability to directly identify their samples as monastic or non-monastic prevents them from linking this lifestyle with DISH. It can be stated that the presence of DISH is indicative of a lifestyle that was shared between monastic and wealthy individuals, as the authors present evidence that monastic and non-monastic wealthy males experienced elevated levels of carbon and nitrogen isotope values (Quintelier et al. 2014: 211).

DISH and the Medici Family

Academic attention has largely focused on the association between DISH and elite lifestyle. While the previous studies attempt to identify DISH among the remains of unknown monks and laymen, Giuffra and colleagues conducted a study on the remains of known elite individuals from the Medici family of Grand Dukes of Tuscany. The Medici family was one of the most powerful families of the Italian Renaissance, as they acquired great wealth as merchants and bankers during the fourteenth century and gained considerable governmental control without holding an official position (Fornaciari 2013: 2). The remains are dated to the sixteenth century and were uncovered from the Medici Chapels of the Church of San Lorenzo in Florence (Giuffra 2010: 103-104). Giuffra and colleagues identified the presence of DISH in the remains of Cosimo I (Duke of Florence in 1537, first Grand Duke of Tuscany in 1569) and Ferdinand I (sixth male son of Cosimo I, third Grand Duke of Tuscany in 1587) (Giuffra et al. 2010: S104).

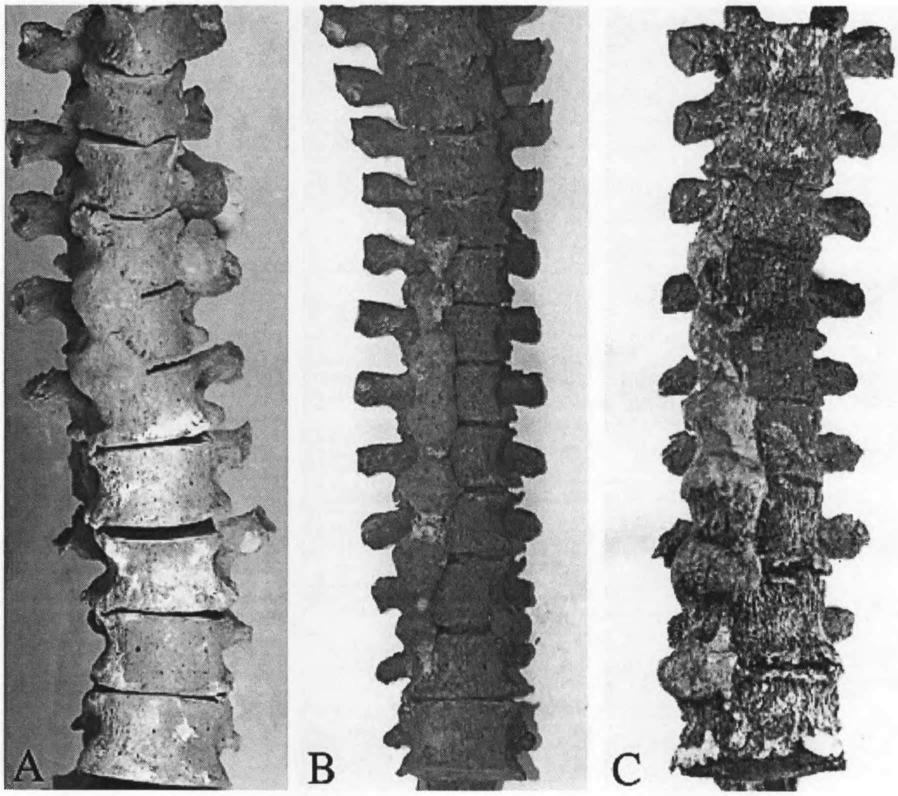


Figure 6.2. The DISH affected areas in [A] Cosimo I, ossification between T6-T8 [B] Ferdinand I, ossification between T5-T11 [C] Cosimo the Elder, ossification between T6-T12 (Fornaciari and Giuffra 2013: 2)

As depicted in Figure 6.2, the characteristics of DISH is evidenced by the distinct flowing ossification of the right thoracic vertebrae in the remains of Cosimo I, Ferdinand I, and Cosimo the Elder. Ferdinand I's remains present a more severe case of DISH with the involvement of the T5-T11 vertebral bodies (Giuffra et al. 2010: S105; Fornaciari 2013: 2). The presence of this pathology among members of the same family indicates that there could be a genetic factor in the expression of this condition; additionally, diet could also play a role in the presence of DISH as these individuals are known to have lived a prosperous lifestyle. It is theorized that the Medici family consumed a diet rich in animal proteins and may have favored the onset of the disease (Fornaciari 2013: 3), and this is supported by the authors' access to historical documentation that detailed the high-animal-protein diets of these individuals (Giuffra et al. 2010: S106).

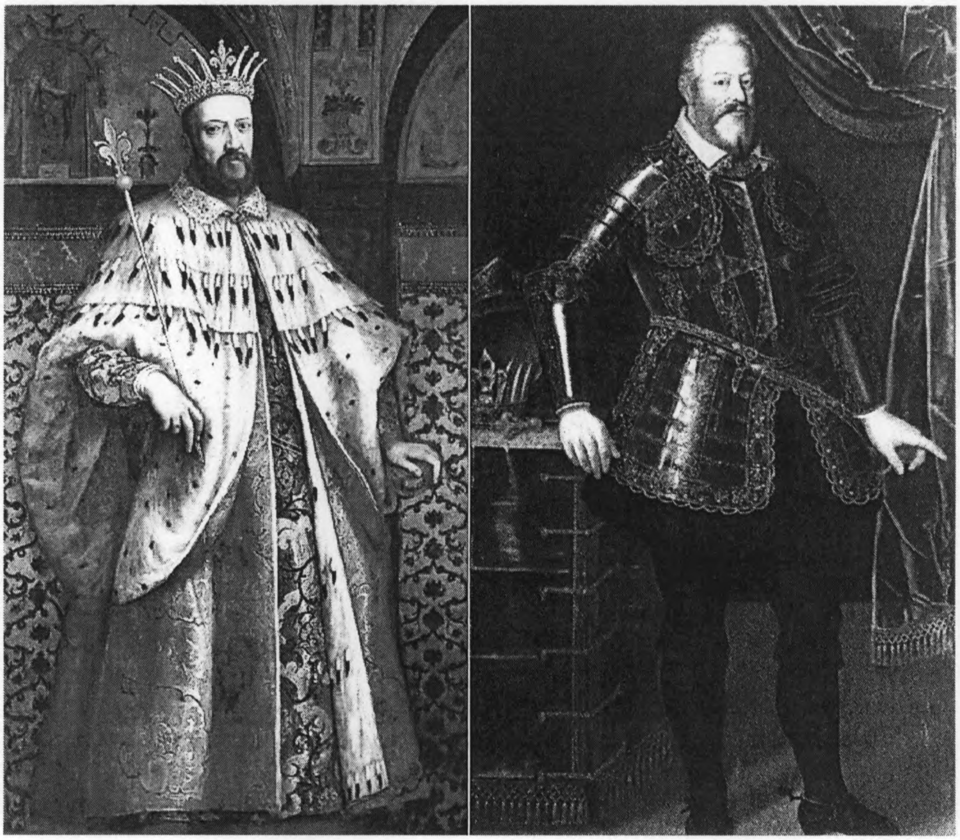


Figure 6.3. Painted portraits of Grand Dukes Cosimo I [left] and Ferdinand I [right] (Giuffra et al. 2010: S104)

Giuffra and colleagues also had access to visual depictions of the individuals they were studying (Figure 6.3). Painted portraits of both Cosimo I and Ferdinand I provide a visual representation of their corporeal conditions, which are described as obese by Giuffra and colleagues (Giuffra et al. 2010: S104). It is important to note that these depictions may not reflect the actual appearance of these individuals; moreover, the images of the Grand Dukes could have been exaggerated in order to appease the commissioners (Francesco 2011: 52). While the previous studies aimed to identify DISH in individuals who cannot be differentiated between monastic individuals and wealthy laypeople, Giuffra and colleagues' analysis of known noblemen with supplementing historical documentation, visual imagery, and isotope analysis provides a strong argument for the association between DISH and a lifestyle of excess and prosperity.

DISH in North America

The majority of DISH studies focus on the prevalence of the pathology in historic European or middle eastern socioeconomic contexts; however, Smith and colleagues present a study that identifies DISH in pre-Columbian cases in the contiguous United States. The authors analyzed burials from four Tennessee village settlements that are dated to the late Mississippian period (1300-1600 AD). The Cox, Ledford Island, Citico, and Toqua sites (Figure 6.4) contained the remains of a maize intensive agriculturalist subsistence economy that are categorized as non-hierarchical and semi-autonomous (Smith et al. 2013: 16). The skeletal sample consisted of 389 adult individuals and was segregated into two general age-at-death categories: young (under 35 years of age) and old (over 35 years of age) (Smith et al. 2013: 12). The authors utilized two categories for diagnosing the samples: DISH (3+ overbridging vertebral bodies) and possible eDISH (2+ overbridging vertebral bodies). The sample revealed only two cases of DISH out of the 389 individuals in the sample (0.5% of population). These two cases came from the Cox and Ledford sites, and both cases are in male individuals with one of whom could not be aged (Smith et al 2013: 13). The mostly complete adult male is estimated to be over 50 years of age; additionally, both Tennessee cases fulfill the conservative diagnostic criteria implemented by Smith and colleagues, which describes the presence of DISH through the ossification of at least four contiguous vertebrae (Smith et al. 2013: 13-14).

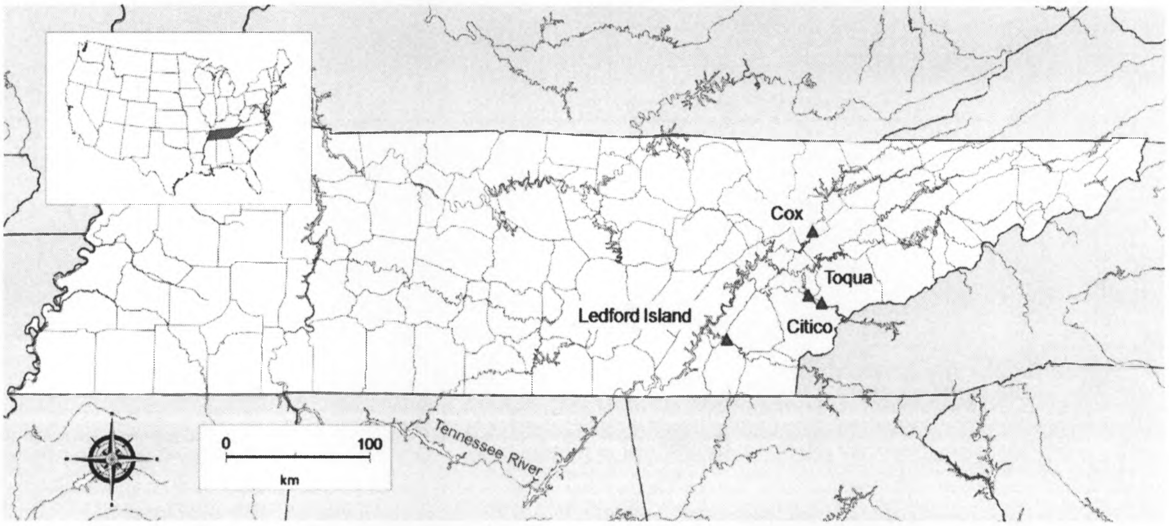


Figure 6.4. Site locations for the Tennessee Late Mississippian period sites (Smith et al. 2013: 12)

The authors suggest that the low prevalence of DISH in the large Tennessee sample is indicative of either a younger age at death which prevents more cases from being expressed, or the absence of health risks that promote the emergence of the pathology among the population (Smith et al. 2013: 15). The frequency of DISH in the Tennessee sample is similar to frequencies encountered in South American burial sites; moreover, the low prevalence of DISH in North and South American skeletal samples suggests that prehistoric New World populations are genetically variable from Old World populations and less susceptible to expressing DISH (Smith et al. 2013: 15). While a plausible theory, further research is needed in identifying which genes are responsible for the expression of this pathology. Although this study analyzes a sample low in DISH affliction, it provides information on the earliest emergence of DISH affliction discovered so far among North American osteoarchaeological samples. However, further research on other samples is required in order to establish the true nature of DISH in North American contexts.

Metabolic Arthritis

A pathology that has been closely associated to both DISH and obesity is metabolic arthritis, which is also referred to as gouty arthritis or gout. Gout is a metabolic disease characterized by hyperuricemia, which is the abnormal accumulation of uric acid in the blood (Minozzi et al. 2013: 3). This elevation of uric acid within the body is often explained by kidney failure, which would cause the organs to produce excessive amounts of uric acid, reduce renal excretion, or a combination of the two malfunctions (Buckley 2007: 743; Minozzi et al. 2013: 3; Johnson et al. 2013: 2222). Elevated uric acid levels create the precipitation of monosodium urate (MSU) crystals, which are deposited into soft tissues within or around a joint and produce small white lumps known as tophi (JAMA 2010: 2314; Minozzi et al. 2013: 3; Nursing Standard 2014: 21). Tophi usually develop after a decade of frequent gout attacks (Nuki and Simkin 2006: S1; Bianucci et al. 2016: e28). The uric acid crystals that accumulate primarily within and around articular surfaces found in the feet (specifically the tarso-metatarsal and metatarso-phalangeal joints), ankles, knees, hands, and wrists; moreover, the crystals promote the erosion of bone and cartilage which results in a chronic and painful arthritis (Minozzi et al. 2013: 3). Gout affliction is strongly correlated with older males; moreover, the peak age for the onset of gout occurs between 40 and 60 years of age (Minozzi et al. 2013: 3; Bianucci et al. 2016: e28).

Table 6.5. Morphological characteristics of metabolic arthritis

Age of onset	Middle/old adult (40-60+ years)
Sex bias	Male
Soft tissue	Accumulation of urate crystals under skin; observable as small white lumps referred to as tophi
Joint appearance	Tophi create cystic erosions within the bone or on outer cortical contour; erosions on joint margins eventually encroach into subchondral bone (Buckley 2007: 743)

The epidemiology of gout is similar to DISH in that its origins are unknown; however, it is one of the oldest diseases reported in archival evidence and early medical literature (Minozzi et al. 2013: 3; Bianucci et al. 2016: e28). Egyptian writings dating as early as 2600 BCE referred to *podagra*, which refers to the arthropathy of the first metatarsophalangeal joint that is characteristic of gout (JAMA 2010: 2314; Zychowicz 2011: 322), and at approximately 200 AD the prominent Greek philosopher Galen was the first to describe the visual appearance of tophi (Nuki and Simkin 2006: S1). Textual descriptions of gout cases among past societies indicate that this is not a pathology restricted to the modern world. Analysis of the history of gout may provide insight on the cultural and environmental conditions that may have promoted the potential for excess body weight and obese to emerge among humans.

The emergence of gout has been attributed to both genetic and lifestyle factors (Bianucci et al. 2016: e28), and these associations are evident in the early writings describing gout among elite individuals. Around approximately 400 BCE, Hippocrates connected gout with high social status when he described this condition as a "disease of kings", as wealthy individuals commonly experienced gouty attacks due to their diets high in meats, sugar, and alcohol (Zychowicz 2011: 322; Johnson et al. 2013: 2224; Nursing Standard 2014: 21). Gout affliction is correlated with increases in societal wealth; moreover, this is demonstrated by the rise of gout cases during periods of prosperity such as during the golden age of Greece, the rise of the Roman Empire, and the Industrial Revolution in Europe (Zychowicz 2011: 322). The association between gout and a lifestyle of abundance resulted in societal discourses that praised the pathology as a socially desirable due to its prevalence among the powerful political and social figures (Nuki and Simkin 2006: S1). Additionally, the idea that gout could be an inherited condition dates to 200 AD when the Cappadocian physician Aretaeus described a specific state of susceptibility regarding gouty attacks (Nuki and Simkin 2006: S1). This idea was expanded upon in the eighteenth century when William Cullen, an Edinburgh physician, described the susceptibility for large, robust men to experience gout attacks especially if their fathers had suffered from the same condition (Nuki and Simkin 2006: S1). The 1967 discovery of a purine enzyme deficiency associated with a rare type of inherited gout provided the scientific background for the genetic contributions to the emergence of metabolic arthritis (Nuki and Simkin 2006: S1).

Contemporary clinical studies indicate a strong correlation between gout and excess body weight, high levels of cholesterols and fats, and high blood pressure (Nursing Standard 2014: 21). Worldwide increases in gout prevalence stems from the industrialization of societies and expansion of a westernized diet and sedentary lifestyle (Nuki and Simkin 2006: S1), which is also correlated to the increase of obesity prevalence. Researchers hypothesize that obesity increases gout risk due to its promotion of insulin resistance, which may be a factor in the presence of hyperuricemia and gout (DeMarco 2011: 1113). The influence of dietary intake on the presence of gout is demonstrated by demographic studies on gout incidence in societies with contrasting diets. The contrast in gout prevalence between Asian and European societies has been attributed to the variation in the consumption of dietary purines, which are contributors to the accumulation of uric acid in the body (Nuki and Simkin 2006: S1). Traditional Asian diets consist of staple foods such as rice and vegetables, which are low in dietary purines (Nuki and Simkin 2006: S1). Thus, gout is a rare condition among these populations. European and American diets, however, are high in meat and seafood proteins, and these dietary staples have higher levels of dietary purines which increases risk for hyperuricemia and gout (Nuki and Simkin 2006: S1). The westernization of societies in recent decades has labeled gout and hyperuricemia as common diseases among contemporary humans (Nuki and Simkin 2006: S1).

Further support for the relationship between gout and obesity is evident in a clinical study conducted by Demarco and colleagues. These researchers analyzed gout-related surveys completed by the CLUE II cohort, which consisted of 15,533 self-reported white adults. The surveys were taken during the years 2000, 2003, and 2007, and it included self-reported data on an individual's health status, sex, race, age, height, weight, weight at 21 years of age, and treatments for high cholesterol and hypertension (DeMarco 2011: 1109). The results indicated that obesity is not only increases the risk for gout affliction but it also promotes an earlier age for the onset of gout. Individuals who were obese at the age of 21 developed gout 11 years earlier than non-obese individuals (DeMarco 2011: 1112). The authors also found that there was a 2-fold minimum increase in the risk of gout affliction among individuals whose BMI increased over 1.88 kg/m^2 before reaching 35 years of age (DeMarco 2011: 1112). This study suggests that excess adiposity in early life will significantly increase risk for developing gout, especially at a younger age for onset. However, this study is limited in that it utilizes data that is self-reported and may not accurately reflect the true nature of the CLUE II cohort.

Gout Identification in Archaeological Samples

Clinical medicine diagnoses gout based on the presence of MSU crystals within the joint fluids of an individual (Swinson et al. 2008: 135-136; Limbrey et al. 2011: 2497). Antoni van Leeuwenhoek was the first to describe MSU crystals through microscopy analysis of a gouty tophus, and he observed how the chalky substance contained transparent and elongated crystals (Nuki and Simkin 2006: S1). Alternatively, the diagnostic criteria for gout in palaeopathology has traditionally relied on the morphological appearance and distribution of erosions on the articular surfaces of skeletal remains (Limbrey et al. 2011: 2497).

Untreated MSU crystal deposition results in irreversible joint damage (Bianucci et al. 2016: e28). Alexander of Tralles, a sixth century AD Byzantine Christian physician, recommended the consumption of colchicine in order to treat acute gout (Nuki and Simkin 2006: S1). This treatment is derived from the flowering plant autumn crocus and effectively treated the painful condition; however, it was known to induce severe gastrointestinal side effects that discouraged its use for gout treatment (Nuki and Simkin 2006: S1). Because past populations did not have sufficient medicine to treat gouty attacks, researchers are inclined to diagnose this condition by analyzing the erosion of bone in osteoarchaeological samples (Bianucci et al. 2016: e28). Erosions on articular surfaces will only develop when gout is severe enough to produce tophaceous deposits within or around joints (Swinson et al. 2008: 141). Because intermittent gout generally resolves after each attack during life, occasional attacks of gout will not leave skeletal markers; therefore, only individuals with severe enough gout can be identified.

While researchers prioritize the analysis of skeletal erosions in osteoarchaeological samples because joint fluid does not preserve in the archaeological record, a study conducted by Limbrey and colleagues provided an alternative method in gout identification through the analysis of MSU crystals in white power or bone particles from a skeletal individual. Limbrey and colleagues' sample consisted of three skeletal individuals from three separate burial sites of varied chronological periods (Table 6.6). The remains from the Bromyard and Lincoln sites exhibited a white powdery substance that was closely associated with the presence of bone erosions attributed to gout (Figure 6.5) (Limbrey et al. 2011: 2498). The individual from Lisbon did not have white powder present on the remains; therefore, the authors took a sample of the bone particles from the eroded bone on the articular surface (Limbrey et al. 2011: 2498).

Table 6.6. Description of site location and skeletal materials (Limbrey et al. 2011: 2498)

Site	Burial Date	Age	Sex	Skeletal Source
Bromyard, UK	19^{th} century	50+ years	Male	Right first metatarsal head gouty articular erosion; white powder
Lincoln, UK	Medieval	50+ years	Male	Left fifth metatarsal shaft gouty erosion; white powder
Lisbon, Portugal	Mid-20^{th} century	68 years	Female	Left first metatarsal head gouty articular erosion; particles of trabecular bone

Limbrey and colleagues' study revealed that MSU crystals can be identified in archaeological remains, thus allowing researchers another method in confidently identifying gout. Analysis of the white powder and bone particles of the three samples indicated that MSU crystals were clearly identifiable at x400 magnification; moreover, the crystals were observed to take on various morphological states (Figure 6.5) while also emitting strong birefrigence, which helps researchers differentiate MSU crystals from other soil minerals (Limbrey et al. 2011: 2498). The identification of MSU crystals through bone particle samples is significant in that it presents an alternative source in gout identification when white powders are not present. However, the authors note that the bone particle samples came from an individual who was buried in an alkaline environment for a shorter amount of time compared to the other individuals, which may have promoted better MSU crystal preservation (Limbrey et al. 2011: 2500).

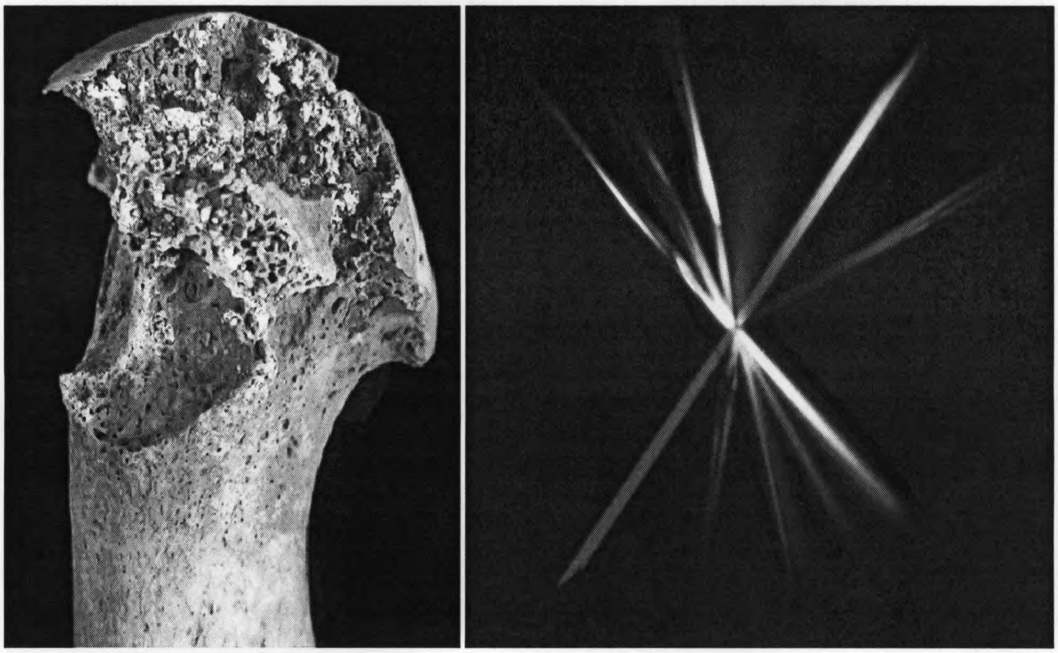


Figure 6.5. Left: The gouty erosions and white powder on the medial side of the right first metatarsal of the Bromyard specimen. Right: A birefringent MSU crystal identified from the Bromyard individual's white powder sample (Limbrey et al. 2011: 2498-2499)

These findings indicate that MSU identification is possible among archaeological samples, and this method could be used to reaffirm a diagnosis of gout. Additionally, the study also determined that MSU crystal deposits can stay preserved on skeletal remains for over 450+ years (Limbrey et al. 2011: 2500). The authors noted their skeletal samples underwent normal examination procedures and were washed prior to analysis; moreover, efficiency in detecting MSU crystals in archaeological remains could be improved with careful handling of specimens suspected of gout affliction (Limbrey et al. 2013: 2500).

Gout and the Medici Family

Further research on gout has been conducted on the remains of a Medici Grand Duke, Ferdinand I. Historic documentation revealed that Ferdinand I suffered from frequent attacks of acute gout on his left foot's big toe from age 33 until death (Fornaciari et al. 2009: 375-376). While DISH was not mentioned in historical writings due to its asymptomatic nature, the painful attacks of gout produces observable swelling and reddening of the affected areas (JAMA 2010: 2314), and the observable physical changes and severe pain characteristic of gout allowed afflicted individuals to be aware of the pathology's presence. In 1582, Ferdinand I wrote a letter to his brother explaining that he was confined to his bed and referred to the severe pain he was experiencing in his gout affected foot (Fornaciari et al. 2009: 376). In 1591, a court physician Giulio Angeli also accurately described a gout attack as he detailed how Ferdinand I's big toe became inflamed overnight (Fornaciari et al. 2009: 376). Analysis of the skeletal remains of Ferdinand I's left foot (Figure 6.6) identifies lesions in the articular surface at the interphalangeal joint region (Fornaciari and Giuffra 2013: 3).

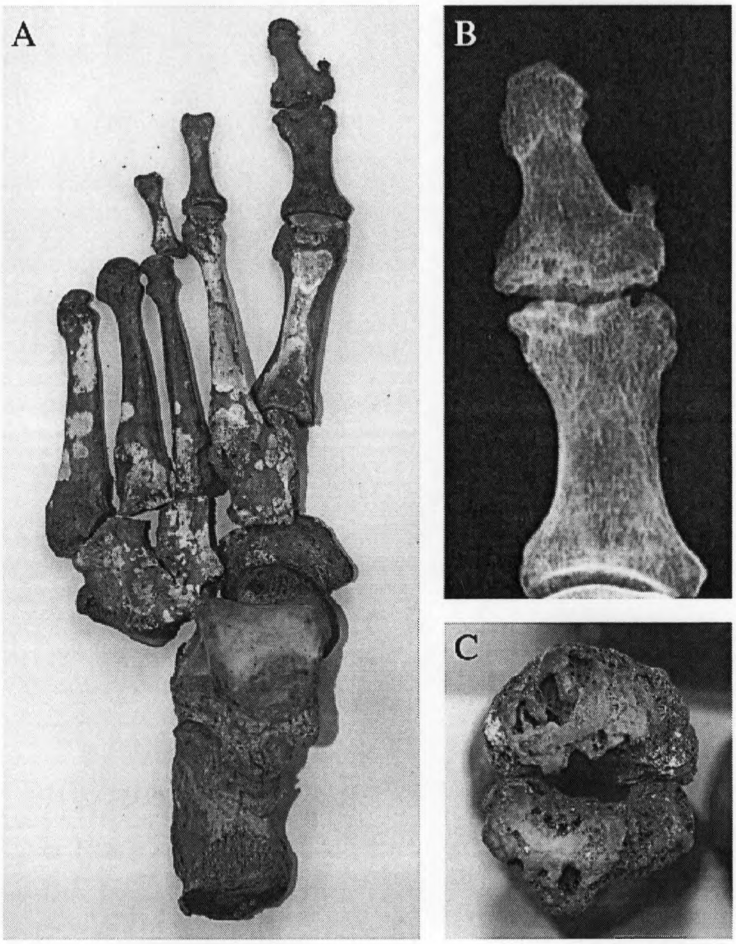


Figure 6.6 Gout in Ferdinand I: [A] Lesion on the left foot at the interphalangeal joint level of the big toe [B] "Scoped-out" defect at the interphalangeal joint of the hallux dorsum in the left big toe [C] Lesions in the articular surfaces of the interphalangeal joint with partial destruction of the subchondral plate (Fornaciari and Giuffra 2013: 3)

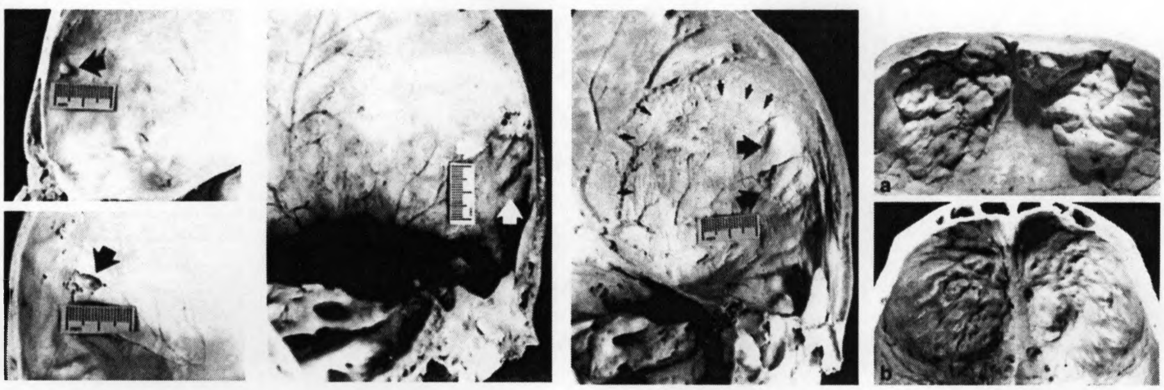
It is hypothesized that Ferdinand I's gout could have been genetically inherited from older family members. The Grand Duke Piero (1416-1469) was widely referred to as Piero "The Gouty" by the public (Fornaciari et al. 2009: 375). Another hypothesis regarding the presence of metabolic arthritis in Medici Grand Dukes is the correlation between gout and the elite lifestyles enjoyed by the Medici family. Aristocratic classes in the Italian Renaissance had access to a wide variety of luxury foods that are commonly associated with gout. Historical data reveals that elite individuals would have consumed a diet rich in wine and varied animal products (such as meat, fish, and eggs) depending on the religious season (Fornaciari et al. 2009: 376). The historical data is supported by carbon and isotope studies on the remains of aristocratic individuals, where high $\delta^{14}N$ and $\delta^{13}C$ levels indicate a varied diet. Analysis of $\delta^{13}C$ levels indicates that the dietary intake of marine proteins among elite Italians was around 14-30% (Fornaciari et al. 2009: 376), which is an example of diet high in dietary purines that are correlated with increased gout risk. Analysis of gout affliction in Ferdinand I is notable in that it presents the first documented case study on the coexistence of DISH and gout within the same osteoarchaeological individual (Fornaciari et al. 2009: 377).

Hyperostosis Frontalis Interna

A third pathology that is associated with obesity is hyperostosis frontalis interna (HFI). This is a condition wherein bone grows excessively in a symmetrical pattern primarily on the internal lamina of the frontal bone, but it can also affect other cranial bones as well (Mulhern et al. 2006: 480). HFI usually does not induce symptoms; however, the extensive protrusion of a bony nodule can compress underlying soft tissues such as the dura and cerebrum, and chronic cerebral compression can result in atrophy of the brain (She and Szakacs 2004: 206; Raikos et al. 2011: 454; Win and Aparici 2012: 116). There are various types of HFI, and the categorization of these types that are commonly used by researchers was developed by Hershkovitz and colleagues in 1999 (Table 6.7). This pathology can be identified from the skull alone, which means that the confidence of HFI diagnosis is not affected by disarticulated skeletal samples (Lazer 2009: 203). The distinct morphological appearance of HFI makes it discernible from other similar pathologies that alter the skull vault (Rühli and Henneberg 2002: 378; Win and Aparici 2012: 417). However, an inexperienced researcher could overlook or confused HFI types A and B for another pathology (Figure 6.7), which could result in the underestimation of HFI among past populations (Devriendt et al. 2004: 417).

Table 6.7. Morphological characteristics of hyperostosis frontalis interna (Hershkovitz et al. 1999: 308-309)

Age of onset	Middle/old adult (40+ years) or post-menopause
Sex bias	Female
HFI Type A	Isolated, elevated bony island in single or multiple clusters; can be unilateral or bilateral; all with discrete and often undermined margins; under 10mm in size and commonly found on anteromedial part of frontal bone
HFI Type B	Bony overgrowth(s) without discrete margins; slight elevation
HFI Type C	Extensive nodular bony overgrowth; associated with irregular thickening of up to 50% of the endocranial surface of the frontal bone; tendency for greater elevation and coalescence
HFI Type D	Continuous bony overgrowth involving more than 50% of the frontal endocranial surface; whole area is variably elevated and usually manifests a sharp demarcation at its borders; unaffected midline flares out towards bregmatic region



HFI Type A HFI Type B HFI Type C HFI Type D

Figure 6.7. Photographs of varying HFI severity (Hershkovitz et al. 1999: 308-309)

The origins of this pathology are still unclear, but researchers commonly link this skeletal condition with metabolic disorders (Flohr and Witzel 2011: 30). This pathology was first described by Morgagni and Santorini in 1769 during an autopsy of an elderly obese woman who also suffered from excessive hair growth (hirsutism) (Nallegowda et al. 2009: 915; Bebel and Golijewskaja 2015: 45). HFI prevalence varies according to adiposity; moreover, it generally occurs more frequently in obese individuals while low prevalence is observed in thinner people (Nallegowda et al. 2009: 915; Bebel and Golijewskaja 2015: 46). HFI has also been associated with virilism, which results in the development of masculine facial features among women (Lazer 2009: 207). Moreover, it is not uncommon for the development of male characteristics on the skulls of older women. HFI was once considered to be part of syndromes linking comorbidities, such as Morgagni's syndrome (HFI, obesity, virilism), Stewart-Morel syndrome (HFI, obesity, mental disturbances), and Troell-Junet syndrome (HFI, acromegaly, toxic goiter, and diabetes mellitus type II); however, research has indicated that HFI is a condition that occurs separately from these associated comorbidities (Hershkovitz et al. 1999: 323; Win and Aparici 2012: 117).

HFI primarily affects postmenopausal women (She and Szakacs 2004: 207; Raikos et al. 2011: 457), and this is evidenced by HFI incidence among contemporary human populations. Clinical studies indicate that HFI affects 5-12% of the general population (She and Szakacs 2004: 207); more specifically, 5% of the affected population were males, 11% were women between 20-29 years of age, and 44.2% were women over 80 years of age (Win and Aparici 2012: 116). Whereas HFI generally manifested among elderly women in past populations, current research indicates that HFI affliction is increasing among younger populations (May et al. 2011: 396). A report on 17 modern patients diagnosed with HFI revealed that all patients were women and 82% of these individuals were obese with a weight excess of 50lbs per person (Raikos et al. 2011: 457). In contrast to the modern population, HFI prevalence in archaeological contexts is quite low as only 1-4% of archaeological crania express indicators of the pathology (Rühli and Henneberg 2002: 378; Bebel and Golijewskaja 2015: 47). This low prevalence could be due to issues regarding the diagnostic criteria for HFI. Underestimation of HFI in archaeological remains could also stem from a lack of inspection of the endocranium among complete skulls, as researchers may assume that HFI would be absent due to the shorter lifespans that inhibited the development of this pathology (Rühli and Henneberg 2002: 380; Lazer 2009: 219; Bebel and Golijewskaja 2015: 47).

It is hypothesized that microevolutionary changes in human hormones contribute to the high HFI frequencies among modern populations. While chapter 5 described the effects of heavy mechanical loading on bone mass, researchers have identified possible hormonal influences on bone growth and metabolism (Reseland and Gordeladze 2002: 40). Hormonal changes occur as response to increased food access and altered metabolic rates, and ideas on microevolutionary hormonal changes attributed the presence of HFI to hormonal imbalances (Rühli and Henneberg 2002: 380; Nallegowda et al. 2009: 915; Raikos et al. 2011: 457). The emergence of HFI has been linked with excess adiposity, and abnormal levels of adipose tissue are linked to irregular levels of leptin and estrogen (Rühli and Henneberg 2002: 379; Nallegowda et al. 2009: 915). Leptin is observed to both stimulatory and suppressive effects on bone growth, as it elicits both osteoblastic and osteoclastic activities (Upadhyay et al. 2015: 4-5; Reseland and Gordeladze 2002: 41). Observations also indicate that leptin may have direct local effects on bone due to its secretion by bone marrow adipocytes (Updahyay et al. 2015: 4).

Theories regarding the origins of HFI also commonly refer to estrogen imbalances. Estrogen functions in the preservation of bone mass while also decreasing bone turnover rates, and abnormal estrogen levels result in the increase of osteoblastic activity (Win and Aparici 2012: 117; May et al. 2011: 395). Because estrogen is a hormone that is produced by adipose tissue, increased levels of bodily adiposity will result in the excessive production of estrogen which may trigger excess bone growth on the frontal bone (Nallegowda et al. 2009: 915). Testosterone levels are also linked with HFI incidence, as it reduces bone resorption while also increasing the lifespan of osteoblasts and osteoclasts (May et al. 2011: 393). Higher levels of androgen hormones in males will inhibit the development of HFI while lower levels in females will promote the production of abnormal frontal bone outgrowths (Bebel and Golijewskaja 2015: 47).

Consequently, males with testicular atrophy and other similar hormonal irregularities will be at a higher risk for HFI affliction (She and Szakacs 2004: 208). The increased frequency and severity of HFI cases in modern populations thus demonstrates the effects of altering our internal and external environments, as evidenced by changes in dietary patterns, hormonal treatments, and fertility patterns (Bebel and Golijewskaja 2015: 46-47; May et al. 2011: 396).

The presence of HFI among archaeological populations is considered rare especially prior to the eighteenth century, and this is based on the findings of a survey conducted by Hershkovitz and colleagues. These researchers examined over 2000 skulls from various geographic areas and eras and encountered an absence of HFI cases in the sample (Hershkovitz e al. 1999: 312; She and Szakacs 2004: 208). However, analysis of 1706 cranial samples dated to the twentieth century reveals that 24% of females and 5% of males were affected with HFI (Hershkovitz et al. 1999: 321; She and Szakacs 2004: 208). Hershkovitz and colleagues' study developed the assumption that HFI is rare among past populations (Devriendt et al. 2004: 417). Because environmental factors are evidence to have a strong correlation with HFI incidence, researchers relate the Industrial Revolution period as a significant marker indicating the rapid emergence and spread of HFI cases among modern humans (Hershkovitz et al. 1999: 323).

HFI in Pompeii, Italy

Lazer's research on HFI frequencies in archaeological Pompeian skeletal collections contradicts the assumption of the absence of this pathology among past populations. The remains are dated to the 79 AD eruption of Mount Vesuvisus and consists of 360 skulls that were preserved well enough for analysis. Identification of HFI in complete skulls was accomplished by analyzing the internal bone through the foramen magnum with the aid of a torch light (Figure 11), and analysis of incomplete crania allowed for the direct observation of the cranial surface (Lazer 2009: 203). Lazer utilized the system proposed by Henschen to diagnose the presence and severity of HFI, and this system is roughly equivalent to the system created by Hershkovitz (Table 6.7) (Lazer 2009: 203).

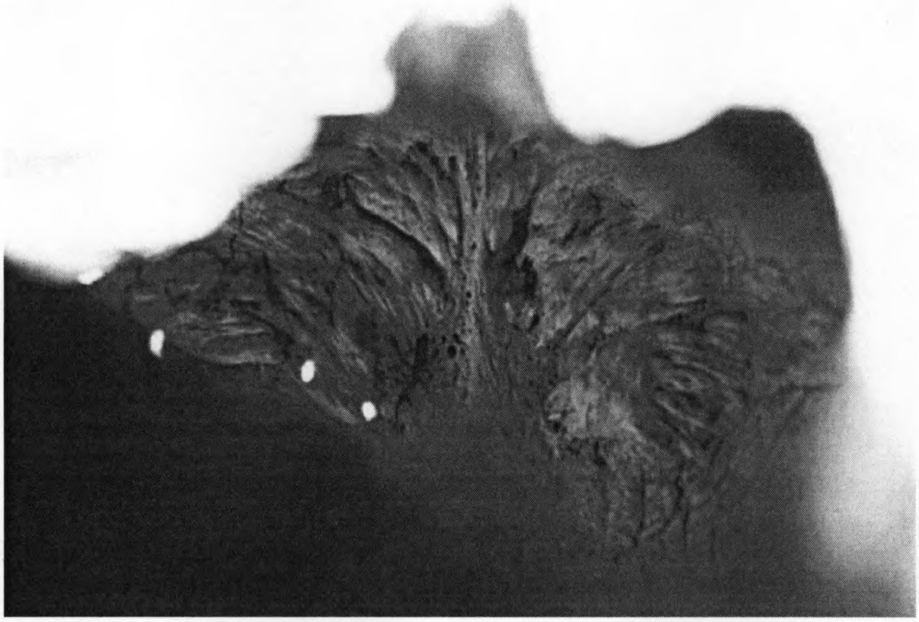


Figure 6.8. View of the extensive severity of HFI through the foramen magnum of TF SND's skull (Lazer 2009: 205)

Survey of these Pompeian samples revealed 43 HFI cases of varying severity. The majority of the specimens displayed only very slight deposits of additional bone on the inner table of the frontal bone (Lazer 2009: 203). Seven specimens exhibited slight bony changes, five exhibited moderate bony changes, one exhibited pronounced bony changes, and one revealed extensive bony tumorous swellings (Lazer 2009: 203). The incidence of HFI is 11.1% in this osteoarcheological sample, which is similar to the upper range of HFI frequency among modern populations (Lazer 2009: 153). Lazer identified the majority of HFI affected skulls as female, reaffirming the link between HFI and sex (Lazer 2009: 206). While some skulls were too incomplete to be estimated for age, Lazer estimated the majority of the skulls to be adults (Lazer 2009: 207). He identified seven individuals over 30, ten individuals over 40, fourteen individuals over 50, and four individuals over 60 (Lazer 2009: 207). Lazer's findings thus presents a strong relationship between HFI and increasing age. Researchers had theorized that HFI would not be present in past populations due to their shorter lifespans, which would have disallowed the expression of the pathology in the skull (Lazer 2009: 212). However, Lazer's study debunks the claim that HFI was rare in antiquity. The high HFI incidence in the Pompeian sample suggests that women were surviving into older ages instead of dying early due to childbirth or disease (Lazer 2009: 154).

The connection between HFI and obesity among Pompeian populations can be elaborated upon by analysis of historical documentation. While it is unclear as to whether obesity directly results in the emergence of HFI, historical texts reveal that obesity was a known condition in the Campania region of Italy. Gaius Plinius Caecilius Secundus (61-113 AD), also known as Pliny the Younger, held positions as a lawyer, author, and magistrate of Ancient Rome. Pliny sent letters to Cornelius Tacticus (58-120 AD) describing the 79 AD eruption of Mount Vesuvius, which includes a description of his mother's and uncle's corpulent bodies (Lazer 2009: 211). An excerpt of Pliny the Younger's letter states, "My mother now began to beseech, exhort, and command me to escape as best I might; a young man could do it; she, burdened with age and corpulency, would die easy if only she had not caused my death" (Pliny 1931: 493-495). Pliny's mother had urged him to leave her behind, as her old age and large body size endangered their survival by slowing down their escape from the volcanic activity (Lazer 2009: 211). Pliny's description also supports the assertion that individuals lived to an old enough age to express corpulency and potentially HFI. Interpretations explaining the high frequency of HFI in the Pompeian population are varied; additionally, there could be a range of activities and factors that could have influenced the presence of HFI. Therefore, it is important for researchers to have extensive knowledge on the cultural contexts of the skeletal sample under investigation.

HFI in Qatna, Syria

The association between HFI and social status is studied in Flohr and Witzel's analysis of HFI frequency among the skeletal remains at the royal palace of Qatna. The royal palace is estimated to have been built between 2000-1650 BCE, and the skeletal sample studied by the authors were located in Tomb VII located underneath the main structure (Flohr and Witzel 2011: 32). A minimum number of 70 individuals are represented in this skeletal population. The authors utilized Hershkovitz and colleagues' HFI classification and identified nine skulls or skull fragments as exhibiting HFI (Table 6.7) (Flohr and Witzel 2011: 33). However, the fragmentary nature of some specimens prevents the authors from determining HFI frequency, as affected skull fragments may belong to one or various individuals.

Table 6.8. Properties of the HFI afflicted remains analyzed by Flohr and Witzel (Flohr and Witzel 2011: 34-38).

Specimen	HFI Severity	Age and Sex
MSH09G-q774-017	Type D	Unknown
MSH10G-q628-340	Type D	Mature male
MSH10G-q190-026	Type D	50-year-old male
MSH09G-q1315-025	Type C	Unknown
MSH09G-q1315-013	Type B or C	Unknown
MSH10G-q453-322	Type B or C	Unknown
MSH09G-q770-020	Type B	Unknown
MSH09G-q606-147	Type B	Unknown
MSH09G-q1311-008	Type A or B	Female

The presence of HFI among the skeletal population of Tomb VII indicates a relationship between HFI and social status. Although male HFI affliction in the Tomb VII sample contradicts studies indicating strong female predilection, this finding is likely skewed due to the small sample size and the inability to determine sex for the majority of HFI affected specimens. The severe affliction of these two male individuals may indicate testicular atrophy or similar hormonal irregularities (Hershkovitz et al. 1999: 322; She and Szakacs 2004: 208). While the age and sex cannot be determined for every specimen, the identification of two older males indicates longevity that contradicts the assertion that HFI could not be expressed in past populations due to short lifespans. An analysis of post-cranial properties including mild joint degenerations and mild dental attrition revealed a lifestyle associated with low physical loading and a nutritious diet (Flohr and Witzel 2011: 41). Additionally, the undisturbed nature of Tomb VII allowed the authors to associate the remains with social status through the presence of grave goods associated with prosperity including gold, pottery, and figurines (Flohr and Witzel: 32).

HFI in Chaco Canyon, New Mexico

A study conducted by Mulhern and colleagues has identified the only known HFI affected samples in pre-Columbian America; additionally, the prevalence of HFI incidence at the site of Pueblo Bonito are unusually high and unexpected. The site of Pueblo Bonito is located in Chaco Canyon, New Mexico, and it constructed between 860-935 AD and functioned as both a high-status residential area and internment site (Figure 6.9); however, analysis of the artifacts associated with the Pueblo Bonito burials suggests that population internment did not occur until 1020-1150 AD (Mulhern et al. 2006: 481). The site consists of 651 rooms that reach up to four stories tall, and the burial clusters are hypothesized to have been based on kinship groups (Mulhern et al. 2006: 480).

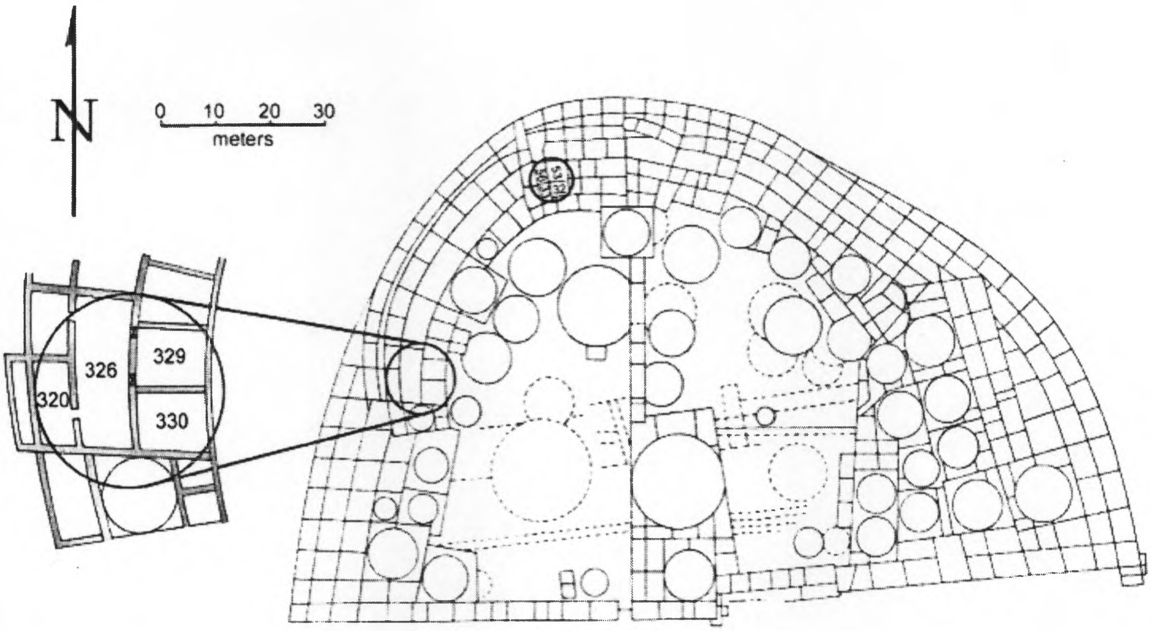


Figure 6.9. Map of the Pueblo Bonito site; circled areas indicate room clusters containing multiple burials. The enlarge circle indicates rooms where the samples analyzed by Mulhern and colleagues were located (Mulhern et al. 2006: 481)

The skeletal sample included the complete or nearly complete frontal bones of 12 adult males and 25 adult females, and the researchers ranked the skeletal specimens on the severity of HFI based on the Hershkovitz's Type A-Type D classification system. Examination of these skeletal samples identified HFI in 12 out of the 37 (32.4%) adult crania. The HFI cases were mainly identified in the female remains, where 11 of the 25 individuals (44.0%) exhibited HFI characteristics (Mulhern et al. 2006: 481). In contrast, HFI was present in only 1 of the 12 (8.3%) male individuals (Mulhern et al. 2006: 481). Variation in the severity of HFI was observed among the samples, and the majority (7 of 12 individuals; 58.3%) of the affected crania were diagnosed with HFI type B, which is characterized by excess bone growth affecting less than 25% of the frontal endocranial surface (Mulhern et al. 2006: 481). Two individuals were afflicted with HFI type A, while three were described as HFI type C with involvement of the parietal bone (Mulhern et al. 2006: 481). The afflicted individuals were generally between the ages of 30-50. The abnormally high HFI frequencies at Pueblo Bonito can be attributed to similarities between the archaeological population and modern populations, and a possible similarity could be the female life and fertility cycles of Pueblo Bonito women and modern female groups (Mulhern et al. 2006: 483). This study also creates an association between HFI affliction and high-status lifestyles; however, the social status of the individuals studied is unclear.

Summary

An indirect analysis of obesity in the archaeological record involves the examination of DISH, HFI, and gout. These pathologies are all associated with obesity; however, the etiologies of these conditions are still debated. It is unknown whether obesity is a causative or associative factor in the presence of these pathologies. A common assertion is that increased age is a major contributing factor to the emergence of these conditions. This could still relate to increasing body fatness. As previously discussed in chapter 3, human evolution required the adaptive strategies of fat to shift as humans age. Pubescent males will accrue lean mass while pubescent females will accrue fat mass in the femoral and gluteal areas in order to raise reproductive success (Wells 2010: 211). However, aging females and males will experience shifts in fat allocation that prioritizes the storage of fat in visceral rather than subcutaneous deposits while simultaneously experiencing a reduction in muscle mass (Wells 2010: 211). Visceral deposits of fat are often associated with abdominal obesity, which could be characteristic of the aging process. The competing biological functions at different life-stages will result in tradeoffs regarding allocation of body fatness, which could explain the increasing risk of DISH, HFI, and gout among aging populations.

Chapter 7: Visual Representations

While an analysis of bioarchaeological materials provides quantitative data and insight on the physical bodies of prehistoric people, analysis of visual representations and ancient iconography provides an indirect method in studying the construction of social and physical bodies of past populations. Visual representations of bodies are commonly depicted in the archaeological record as anthropomorphic figurines, sculptures, and painted portraits. Interpretation of the social categories that are both present and absent among anthropomorphic figurines allows for researchers to analyze possible constructions of social identity among prehistoric societies (Lesure 1997: 229). This chapter provides a description and analysis of the archaeological media used to communicate information regarding the physical and social bodies of the past. This chapter also analyzes the various conflicting theories regarding the meanings of fat and obese bodies in archaeological materials. The first major section presents examples of fat anthropomorphic figurines and analyzes the conflicting interpretations that surround these Palaeolithic and Neolithic figurines. This includes theories regarding obesity representation, body idealization, and self-perspective. This section also includes an analysis of academic assumptions that are generated by figurine researchers. The major second section focuses on fat and obese bodies in archaeological sculptures and painted portraits from Greek, Roman, Etruscan, Egyptian, Mesoamerican, and Swiss populations. An analysis of corporeal representations among cross-cultural groups will demonstrate the way in which varying social values affect body preferences and idealizations.

Anthropomorphic figurines

Anthropomorphic figurines of various body morphologies are prevalent in the archaeological record. Anthropomorphic figurines are often dated to the Aurignacian (43,000-26,000 BP), Gravettian (33,000-24,000 BP), and Solutrean (22,000-17,000 BP) periods of the Upper Palaeolithic (King 2015: 206). Upper Palaeolithic figurines have been discovered in sites spanning across France to Russia, and most figurines are created from various materials including bone, ivory, stone, and clay (Shewan 2006: 439; Nesbitt 2001: 54). These figurines are commonly referred to as “Venus” figurines. The majority of scholars use this term as a reference to the assumed associations with femininity and fertility themes. The Venus of Hohle Fels (Figure 7.1) is dated to 35000 BCE and is referred to as the oldest figurine depicting the human body (King 2015: 206). Alternatively, the Venus of Moruz is considered the most recent corporeal figurine, as it dates to 11000 BCE (King 2015: 206). The second group of anthropomorphic figurines is dated to the Neolithic period (7000-1700 BCE), and Neolithic figurines are generally spread across Eastern Europe and Mediterranean regions (Nesbitt 2001: 54).

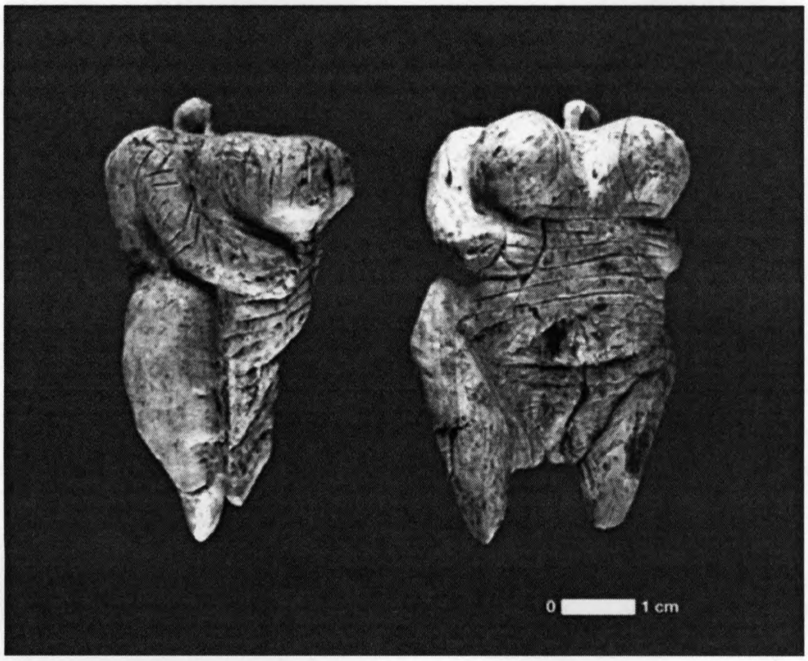


Figure 7.1. Lateral and frontal views of the Hohle Fels figurine (Nowell and Chang 2014: 564)

An archaeological study of obesity through the analysis of anthropomorphic figurines is problematic in that there exists no concrete evidence documenting their purpose and possible functions (if any). Consequently, researchers are restricted to speculation regarding the possible functions and roles of these figurines. The lack of direct explanation prevents archaeologists from knowing why these large body shapes are represented. Scholars have produced various contrasting theories regarding the possible purposes of these figurines, including theories that figurines may have served as votive offerings, idealizations of a desired body type, or have an unknown function incomprehensible to modern scholars (King 2013: 1; Nuttall 2015: 117). Interpretations of these figurines are continuously developing, and common themes include ideas on fertility, femininity, beauty, age, and an idealized body. An issue with the theories surrounding these enigmatic figurines is that while many hypotheses regarding the origins and functions of these artifacts are plausible, very few are testable (Tripp and Schmidt 2013: 54). The following sections will analyze these themes within interpretations of figurines as literal reflections of human bodies, idealized corporeal representations, and the self-perspectives of the female body.

Figurines and Obesity

An indirect measure of obesity is an analysis of anthropomorphic figurines; however, it is debated whether these figurines are literal representations of obesity. Although these figurines are frequently depicted as excessively fat and round, the physical condition of obesity is contradictory to the active physical lifestyles of mobile hunter-gatherer groups (Shewan 2006: 439). However, analyzing Upper Palaeolithic and Neolithic figurines as literal representations of the body supports the idea that prehistoric humans valued the advantageous qualities that excess fat may have offered during stressful ecological conditions.

A common question faced by figurine scholars is whether these figurines are true depictions of obesity or artistic representations of the body. Trinkaus attempts to answer this question by analyzing the physical features of figurines and juxtaposing this data with modern obese bodies (Trinkaus 2005: 264). Trinkaus' study focuses on the physical morphology of a Gravettian female figurine known as the Venus of Willendorf (Figure 7.2). This limestone figurine was discovered in Austria and is dated between 25,000-

23,000 BP (Trinkaus 2005: 264). Trinkaus utilizes Pontius' method of iconodiagnosis, which applies contemporary medical knowledge in the interpretation of archaeological iconography (Pontius 1986: 544). Moreover, Trinkaus argues that the Willendorf statuette accurately depicts the body of a modern anatomically-accurate obese woman based on the detailed fat deposits and bodily proportions. If the Willendorf statuette was realized as a proportional human being, she would be under five feet tall and weigh between 176-198lbs (King 2015: 207) resulting in a minimum BMI of 35.5 that indicates clinical obesity. Trinkaus argues that obesity is diagnosable in the Willendorf statuette based on the medically accurate details of the flesh folds and layers of subcutaneous fat (Trinkaus 2005: 264). The Willendorf figurine presents a lack of steatogypia based on the deficiency of adipose tissue on the buttocks and thighs (Krut and Singer 1963: 181); however, the enlargement of the mons pubis and breasts are symptomatic of obesity as observed among modern women. The mon pubis is a fat pad covering the pubic symphysis in human females; moreover, the mon pubis and breasts are observably affected by obesity due to their substantial composition of adipose tissue (Trinkaus 2005: 264-265).

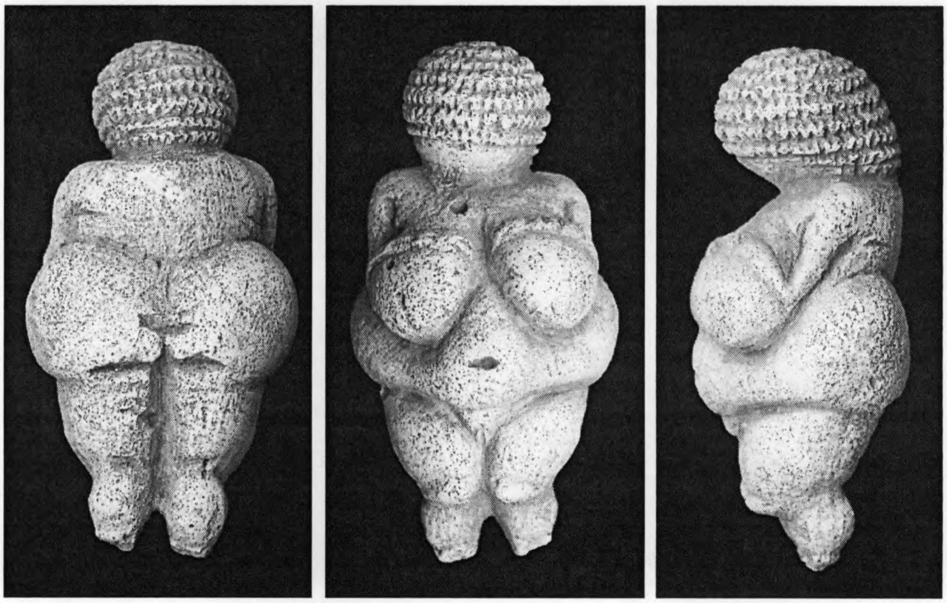


Figure 7.2. Dorsal, ventral, and lateral views of the Willendorf figurine (Trinkaus 2005: 264)

An argument against Trinkaus' assertion is that these figurines are artistic representations rather than literal reflections of the human body (Ferrucci et al. 2009: 53). Trinkaus agrees that figurines such as the Willendorf Venus indeed display stylistic creativity, but he argues that these creative designs are manifested in the upper limbs and head of the Willendorf statuette rather than in the distribution of adipose tissue among the figurine body (Trinkaus 2005: 266). Creative decisions were based on the presence of adornments on the figurine body, but Trinkaus maintains that the corporeal morphology is not exaggerated or artistically modified. According to Trinkaus, the Willendorf figurine exhibits morphological characteristics that accurately depict a medically obese woman. If this assertion is true, the question remains as to why these fat figurines were originally produced. What is the significance behind creating and preserving these body shapes as a figural artifact, and what role did these figurines play in prehistoric life? While researchers can only speculate on the purposes for these figurines, it is frequently theorized that these figurines were constructed based on the value placed on fertility and aesthetics.

Figurines as Idealized Bodies

A common explanation for the presence of fat and obese bodies in archaeological iconography is that these visual representations depict an idealized body that would have promoted survival during periods of scarcity and stress. Researchers hypothesize that prehistoric foraging societies likely would have encountered periods of extreme food shortages and famine (Brown and Konner 1987: 36). Resource scarcity may have affected the social values humans placed on body fatness, and the importance Palaeolithic populations placed on abundance may have been reflected in the bodies and fertility of women (Durmus et al. 2016: 653). Additionally, fatness could have been perceived as an advantageous adaptation that promotes survival. The link between these figurines and the concepts of prosperity and fertility is based on a variety of characteristics. The surplus of flesh is symbolic of fertility due to its aid in successful conception and pregnancy (Kocjan and Giannini 1993: 23). Fertility theories also stem from the presence of red ochre on a number of Palaeolithic figurines, which researchers interpret as symbolic blood, life, and the production of life through pregnancy (Petru 2006: 206; Zagorska 2008: 115).

Figure 7.3. Left: The Sleeping Lady figurine discovered at Hal Saflieni
Right: Androgynous skirted figures found in the Brochtorff Circle (Hill 2011: 7-8)

The desire for a specific body type is known as body idealization, and it is theorized that prehistoric populations would have begun to develop a desire for excess body fatness to achieve higher rates of survival during stressful environmental conditions (Raisborough 2016: 26). The concept of body idealization has been used to explain the function of fat figurines found in Neolithic Maltese burial sites between 3,500-2,500 BCE (Figure 7.3) (Hill 2011: 6). At approximately 2500 BCE, Malta experienced ecological degradation and overpopulation, making resources scarce (Hill 2011: 8). As a result, scholars believe that the placement of fat figurines in burial chambers is symbolic of promising the deceased an "idealized" and prosperous afterlife (Hill 2011: 6). This hypothesis links fat with qualities of prosperity and abundance, which were absent during this stressful period of Maltese prehistory.

Fertility and Waist-to-Hip Ratio Preferences

Aside from fat functioning as energy reserves during periods of scarcity, the distribution of fat on the waist and hips is often associated with fertility levels among females. Researchers have conducted studies attempting to support the figurines' associations with fertility by identifying the waist-to-hip ratios (WHR) of the Upper Palaeolithic figurines. As mentioned in chapter 3, researchers utilize WHR as an indicator of the hormonal profile and reproductive status of women (Hughes and Gallup 2003: 174). These ratios are often correlated with fertility, beauty, health, age, and body shape among women; moreover, a WHR between 0.67-0.8 is argued to be the optimal range for fertility and is expressed as an hourglass body shape (Hughes and Gallup 2003: 174; Singh and Singh 2011: 726; Tripp and Schmidt 2015: 54-55). Women with low WHR have been observed to have fewer irregular menstrual cycles, optimal sex profiles, ovulate more frequently, and have lower endocervical pH which favors sperm penetration (Singh and Singh 2011: 726), and these observations link WHR with the concept of fertility. An analysis on women participating in artificial insemination programs reveals that body fat distribution as measured by WHR increases the probability of successful conception, thus linking fat distribution rather than overall body mass with fertility (Singh and Young 1995: 485). WHR has also been used as an indicator for pregnancy, as WHR generally increases after a woman has been pregnant (WHO 2008: 8). WHR also allows for a direct analysis of obesity, as abdominal obesity is indicated by a WHR above 0.9 for males and 0.85 for females (WHO 2008: 27).

An issue with the fertility theory is the assumption that these fat figurines are assumed to be associated with femininity. It is suggested that the majority of Palaeolithic figurines are women, and Palaeolithic women were likely privileged due to the importance of their physiological roles as reproductive partners and mothers (Duhard 1993: 83; Durmus et al. 2016: 653). Studies on Upper Palaeolithic figurines often indicate an absence of male figures (Shewan 2006: 439); however, this absence is assumed due to the assignment of large breasts and buttocks as female traits. Because obesity produces enlarged breasts, buttocks, and bellies on the male body, figurines that are lacking detail in genitals cannot be confidently sexed.

Notable studies on WHR of Upper Palaeolithic figurines have provided further insight on the relationship between fat prehistoric figurines and the concepts of fertility and beauty. King analyzed figurines specifically from the Gravettian, Solutrean, and Aurignacian periods, and he constructed waist-to-hip ratios by creating measurements on photographs and replica/original figurines when available (King 2013: 2). Some figurines carved from soft stone may have been worn down over time, which prevented measurements from being made. Aside from two figurines, King found that most figurines had a waist-to-hip ratio of 0.7; however, the sample size was quite small as WHR was identified for only 14 figurines (Table 7.1) (King 2013: 3). King asserts that male preferences track female fertility patterns, and an analysis of prehistoric waist-to-hip ratios will provide insight on the male preference for fertility (King 2013: 1). As mentioned in chapter 3, adiposity plays a greater role in relaying reproductive fitness in females than in males, and female fat deposits may have become sexually attractive to males due to its communication of the reproductive value of a woman (Pawowski 2001: 572; Wells 2010: 187). Therefore, these preferences have become ingrained among humans, as males without these preferences are thought to have been unsuccessful in reproducing (Singh and Singh 2011: 724; King 2013: 1).

Table 7.1. Range of WHRs of Upper Palaeolithic figurines as identified by King (King 2013: 2)

Figurine	WHR
Willendorf Venus	0.73
Hohle Fels Venus	0.77
Venus Impudique	0.72
Kostienki Venus Figurine #3	0.68
Venus of Laussel	0.74
Mal'ta figurine 1	0.64
Mal'ta figurine 2	0.66
Mauren Venus	0.75
Venus of Menton	0.78
Yeliseevichi Venus	0.56
Lespugue Venus	0.50
Galgenberg Venus	0.71

A study that challenges King's theory is Tripp and Schmidt's analysis of WHR of Palaeolithic figurines. The authors cited a study by Guthrie, who analyzed 53 Palaeolithic figurines and found the average WHR to be 0.655; moreover, this study argued that the figurines are representative of beauty and palaeo-erotica due to the mean WHR being just outside the optimal fertility ranges (Guthrie 2008: 339; Tripp and Schmidt 2013: 56). While Guthrie and King both estimated WHR through photographic materials, Guthrie's WHR average is much smaller due to his larger sample size. Tripp and Schmidt conducted their study in order to test Guthrie's findings and either reaffirm or refute the relationships between the Palaeolithic figurines, fertility, and beauty. In contrast to King's and Guthrie's WHR collection methods, Tripp and Schmidt obtained WHR by measuring the originals and casts of the figurines. The authors avoided sampling WHR from photographic materials due to the discrepancies that arose when comparing WHR obtained from photographic media with WHR recorded from the statuettes themselves (Tripp and Schmidt 2013: 56). WHR was identified for 29 out of 69 (42%) statuettes; moreover, the results indicated a mean WHR of 0.97 while the mean for figurines from the Russian Plains was higher at 1.15 (Table 7.2) (Tripp and Schmidt 2013: 56-57). The results produced by Tripp and Schmidt significantly contrasts with King's and Guthrie's studies, and this indicates that the theories surrounding fertility based on optimal WHR ranges among figurines are inaccurate.

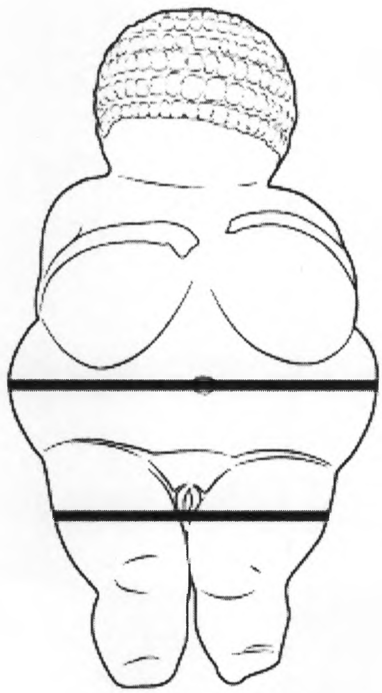


Figure 7.4. Waist-to-hip ratio measurements conducted by Tripp and Schmidt (Tripp and Schmidt 2013: 57)

Table 7.2. Range of WHRs of Upper Palaeolithic figurines as identified by Tripp and Schmidt (Tripp and Schmidt 2013: 57)

Figurine	Region	WHR
La fillette of Brassempouy	Western Europe	0.940
Laugerier-Basse	Western Europe	1.000
Venus of Dolní Věstonice VI	Central Europe	0.933
Venus of Galgenberg	Central Europe	0.790
Venus of Moravany	Central Europe	1.000
Venus of Pavlov	Central Europe	0.800
Venus of Petrokovice	Central Europe	1.030
Venus of Willendorf	Central Europe	1.290
Kostenki X	Russian Plain	1.130
Kostenki torso	Russian Plain	1.220
Eliseevichi	Russian Plain	0.580
Gagarino, stat. 2	Russian Plain	1.510
Gagarino, stat. 3	Russian Plain	1.240
Gagarino, stat. 4	Russian Plain	1.260
Kostenki I, stat. 1	Russian Plain	1.190
Kostenki I, stat. 2	Russian Plain	1.070
Kostenki I, stat. 3	Russian Plain	1.400
Kostenki I, stat. 4	Russian Plain	1.020
Kostenki I, stat. 5	Russian Plain	1.000
Kostenki I, stat. 87	Russian Plain	1.220
Kostenki I, stat. 83-2	Russian Plain	1.110
Malta 74	Siberia	0.890
Malta 370/746	Siberia	1.000
Malta 370/747	Siberia	0.920
Malta 370/753	Siberia	1.000
Malta 370/750	Siberia	0.960
Malta 370/755	Siberia	1.000
Malta 370/756	Siberia	0.980
Malta 370/761	Siberia	0.940

Evolutionary theory suggests that adapted traits which evolved to enhance survival could be interpreted as attractive by other humans (Singh and Singh 2011: 724). The exaggerations in female sexual traits present a preoccupation with female sexuality, and researchers commonly assume that the creators of these figurines were males who produced these representations for the entertainment and enjoyment of other men (Nesbitt 2001: 54). This also creates the assumption that the nude female body is indicative of erotica that served as a form of prehistoric pornography (Nesbitt 2001: 55; Klein 2001: 22). Palaeolithic and Neolithic figurines of women's bodies are often described as objects of desire, and King draws a comparison to modern male adolescents in order to demonstrate the relationship between these figurines and prehistoric lust. He explains how pubescent males surround themselves with models of things that they desire, such as visual media depicting sexualized images of the female body (King 2015: 206). King asserts that the creation of these prehistoric female figurines could be the prehistoric method used by males to convey their desires.

However, an issue with King's hypothesis is that it assumes that males and not females were the creators and possessors of these figurines. Soffer and colleagues argue that women are the likely creators of these statuettes, and they support their hypothesis by focusing on the clothing worn by Gravettian figurines. An initial analysis of the figurines indicated that woven clothing was present only on figurines that the researchers identified as female, and the authors argue that Gravettian women were likely weavers and basket-makers within their communities (Soffer et al. 2000: 525; Soffer et al. 2000: 14). The authors speculate that the creators of these statuettes figures were knowledgeable with fiber technology, and the authors assert the Palaeolithic women's skill in weaving clothing would link them to being the creators of these figurines (Soffer et al. 2000: 525). However, Soffer's and King's arguments are based on generalized assumptions on the roles of Palaeolithic men and women.

In contrast to Soffer and colleagues, King analyzes bodily attire in order to support his theory regarding fat Palaeolithic figurines as objects of desire. He focuses his study on figurines found at a Russian steppe site at Kostenki, where archaeologists found figurines of various morphologies ranging from short and heavy to tall and slender. King interprets these variances as separate female populations that were brought into the

Kostenki site as captives (Figure 7.5). King notes that the fatter figurines display a decorative adornment that he compares to modern bondage techniques. The fatter females have a carving that on the upper torso that is similar to basic bondage techniques such as wrist-ties and chest-ties, and King interprets these bounded females as captives that were forcibly brought to the site (King 2015: 208-209). While King's interpretations provide the theory that these figurines could represent a prehistoric male's desire for a captive female, researchers can only speculate on the processes of female abduction in prehistoric societies due to lack of concrete evidence.

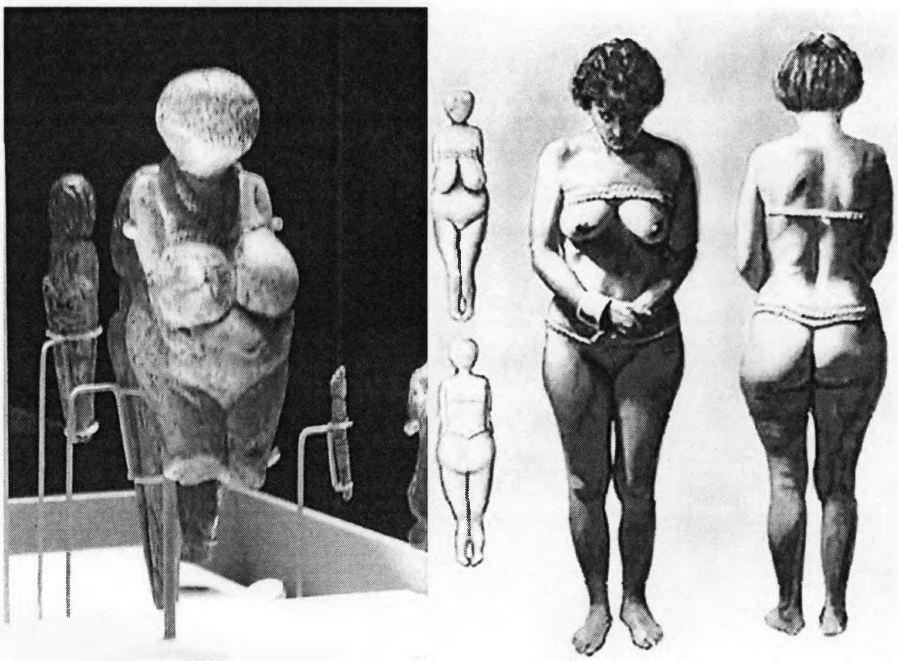


Figure 7.5. Left: Contrast between fat and slender Kostenki figurines (King 2015: 207)
Right: Comparison between a figurine and a bounded captive woman (King 2015: 210)

Researchers such as King believe that these figurines could have been idealized female bodies, and the idea of these figurines as erotica also leads to the idea that these figurines could also be representative of pregnancy and maternity. Researchers have hypothesized that he waist-to-hip ratios are indicative of optimal fertility levels that increase chances of conception and carrying a baby to term. Additionally, analysts have interpreted breast shape with reproductive indicators where non-sagging breasts indicate no or few offspring (paucigestes) while sagging breasts are indicative of many offspring (multigestes) (Duhard 1993: 87). An overwhelming number of figurines is frequently identified as female, and various researchers have hypothesized that preindustrial females who lived in stressful environments would need to produce enough adipose tissue in order to increase their reproductive fitness (Brown and Konner 1987: 38). Other research studies identify the extra reserves of subcutaneous fat as a biological adaptation that aids women through the stages of pregnancy and lactation (Trinkaus 2005: 269).

Figurines and Longevity

New developing theories are challenging the figurine pregnancy and fertility theories. Nakamura and Meskell's analysis of figurines from the Neolithic site of Çatalhöyük indicate that these representations are symbolic of the concepts of abundance and maturity rather than values of fertility or matriarchy (Nakamura and Meskell 2009: 215). Nakamura and Meskell's sample consisted of 446 anthropomorphic figurines that were discovered in non-special deposits such as midden, housefill, and external areas of Çatalhöyük (Nakamura and Meskell 2009: 207). The placement of these figurines in these domestic areas indicate that statues are not objects based on wealth or ritual; instead, these figurines are ever-present objects that may have played numerous roles in everyday life (Nakamura and Meskell 2009: 226). Nakamura and Meskell analyzed these figurines by looking at the presence, absence, exaggeration, and attenuation of bodily traits. The most commonly depicted traits on these Çatalhöyük figurines include enlarged breasts, buttocks, and bellies (Nakamura and Meskell 2009: 211). The authors explain that the exaggerated breasts, buttocks, and stomachs of the figurines prompt researchers into developing interpretations of fertility and pregnancy (Nakamura and Meskell 2009: 212); however, researchers who propose these ideas are most likely interpreting these figurines based on their own contemporary ideas.

Nakamura and Meskell explain that western researchers perceive the enlarged figurine breasts, buttocks, and stomachs based on their own westernized ideas on female sexuality; moreover, this creates an issue where these values may or may not have held the same connotations within the Neolithic societies that created these figurines (Nakamura and Meskell 2009: 208). Other figurine characteristics that are associated with the enlarged breasts, bellies, and buttocks are headless-ness and depictions of fingers and navels, which suggests an emphasized attention towards bodily features rather than adornment, but also not exclusively on female reproductivity (Nakamura and Meskell 2009: 215). The breasts on figurines are often represented as drooping and angular (Nakamura and Meskell 2009: 220), which is indicative of an aging female body rather than a young fertile one. While this study challenges pregnancy theories surrounding prehistoric figurines, Nakamura and Meskell also provide an argument supporting the idealized body concept as it is assumed that the creators of these figurines are demonstrating their appreciation for mature bodies which were successful in surviving through the stresses of prehistoric life.

Jozsa's research on Upper Palaeolithic figurines also challenges the assumptions linking these figurines with female fertility (Jozsa 2011: 243). After analyzing 97 Upper Palaeolithic female figurines from areas in Western Europe, Jozsa discovered that only seven figurines are accurate depictions of advanced stages of pregnancy (Jozsa 2011: 243). Jozsa states that the figurines display a number of pathological conditions such as steatopygia, genu valgum, genu varum (Jozsa 2011: 243). Moreover, the presence of these medical conditions which are observable among modern humans suggests that these figurines present literal reflections rather than exaggerations of human bodies. Jozsa notes that these figurines date back to an era where frequent famine periods would have made obesity rare; however, the high number of obese bodies present in this collection contradicts the idea that obesity would not have been prevalent during the Palaeolithic era (Jozsa 2011: 244). The author also hypothesizes that obese bodies during this stressful time would have been seen as aesthetically desirable (Jozsa 2011: 244). The concept of idealized bodies is also present in this analysis, as Jozsa argues that obesity is a desirable trait that represents survival and access to resources. However, these arguments rely on the researcher's assumptions as there is no method of knowing the true reason behind the fat bodies of prehistoric figurines.

Figurines and Self-Representation

While various researchers have hypothesized that prehistoric figurines are representative of idealized bodies, McDermott focuses on these figurines as products of prehistoric women's self-perspectives (McDermott 1996: 227). The previous theories all assume that these figurines were depictions of other human subjects within prehistoric societies, but McDermott argues that these statues were created from a woman's own point of view (McDermott 1996: 227). McDermott tests this autogenous theory by photographically recreating the self-perspectives of female modern bodies and comparing the visual results with the physical characteristics of the prehistoric Venus figurines. In order to create a representation of a complete body, McDermott argues that at least six different self-perspectives are required. These self-perspectives include head and face, superior anterior (upper frontal surface of the body), inferior anterior (lower frontal surface of the body), inferior lateral (lower side surface of the body), inferior posterior surface of the body, and under-the-arm and over-the-shoulder views (McDermott 1996: 237).

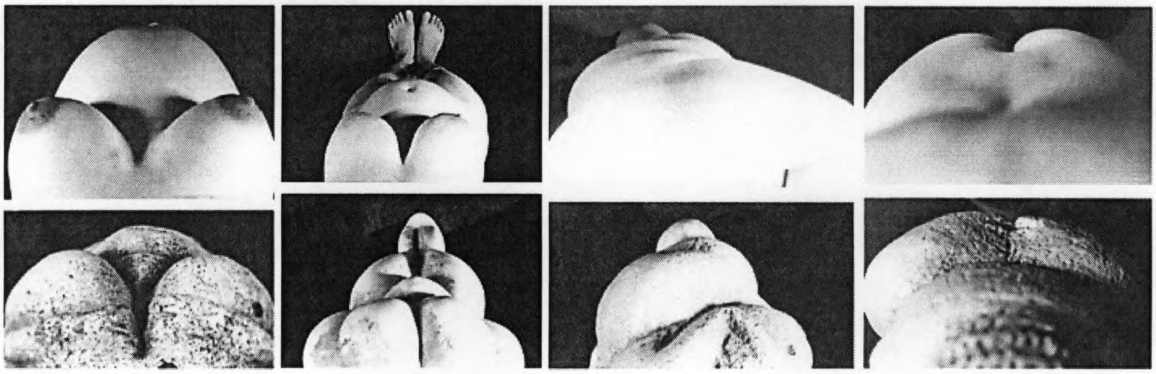


Figure 7.6. Four perspectives of the female body [top images] compared to figurines [bottom images]. The comparison between a pregnant woman with figurine is shown on the far left. (McDermott 1996: 239-240)

Through these various self-perspectives, women are able to observe the exaggerated body parts as depicted in fat female figurines. While Trinkaus argued that the Venus of Willendorf's thin upper limbs were stylistic representations, McDermott argues that this characteristic is the result of the distorted image that is produced when looking down onto the self's body (McDermott 1996: 242). Moreover, this perspective would minimize the presence of limbs based on their distance as seen from an upright perspective. McDermott's text also provides photographic evidence depicting the similarities between bodily characteristics of the Venus of Willendorf and a modern 26-year-old pregnant woman with a size 34C bust (Figure 7.6) (McDermott 1996: 239-240). While McDermott's hypothesis is progressive in assuming that women played a role in the production of these figurines rather than men, this hypothesis also supports pregnancy theories as illustrated by the comparison of a figurine and a woman in the advanced stages of pregnancy. This study provides an important perspective on the identification of obesity, body fat, and body image in prehistoric figurines. As demonstrated by McDermott's study, these figurines may not be representations of obesity at all; rather, they would be products of the distorted visualization of the female self.

If McDermott's self-representation theory is true, the question of why these figurines were produced in the first place remains. It is proposed that these figurines had practical use in encapsulating knowledge and information. Nesbitt explains that theories on prehistoric figurines have evolved from patriarchal and western assumptions into ideas with women as active producers of these artifacts (Nesbitt 2001: 62). The production of prehistoric figurines is thought to have been for the purpose of sharing knowledge of the female body. Just as modern physicians display anatomical images in their offices to educate their patient, these figurines could encapsulate knowledge and information on the female body regarding reproductive and other biological functions (Nesbitt 2001: 56). These figurines therefore serve to provide a better understanding of the female body and are used as educational tools that spread and retain information (Nesbitt 2001: 56). However, analysis of these archaeological materials reveal that the true purpose of these figurines will never be known, and researchers may only speculate the original functions of these artifacts.

Academic Assumptions

An issue with an analysis of prehistoric visual representations is the development and application of false assumptions in interpreting the possible functions of these visual representations. A major issue is presence of colonial and male biases in the analysis of anthropomorphic figures. This includes the reference to prehistoric media as artwork. The term "art" is a problematic term that may be devoid of meaning in prehistoric societies (White 2003: 10). Nineteenth and twentieth century ideas define art as the creation of objects that have significant form and beauty (Conkey 1997: 178), and the purpose of anthropomorphic figurines may transcend the mere function of aesthetic beauty. Visual representations are also historically and culturally conditioned, and the interpretation of prehistoric materials as artwork implicates modern Western ideals onto these objects (Conkey 1997: 178; White 2003: 20).

Analyzing previous academic studies on bodily forms also reveals how western societal discourses have affected the interpretation of Palaeolithic and Neolithic materials (Rountree 2003: 29). These biases were initially established by early nineteenth century academics, who created literature conveying their negative perceptions of fattening practices in non-western societies (Pollock 1995: 358; Forth 2012: 235). Excess fatness was perceived as an "uncivilized" trait attributed to "primitive" societies because it deviated from European norms (Pollock 1995: 358; Forth 2012: 219). Early nineteenth century research conducted by Western scholars on the topic of fatness in non-Western societies also displays evidence of underlying racism within these arguments. One example is the mid-nineteenth century account of the Swedish trader Charles Andersson, who described the African king Nangolo dhAmutenya of Ondonga as "unwieldy" and "ungainly" (Forth 2012: 221; Shigwedha 2006: 120). Andersson also sarcastically stated, "If obesity is to be considered as a sign of royalty, then Nangaro is every inch a king" (Forth 2012: 221). Excessively fat bodies stray from Western societal standards, which influences negative discourses that encourage prejudiced attitudes towards obese individuals. White also presents an example illustrating Western man's fascination with steatopygous buttocks which is typically associated with members of the Bushman and Hottentot of Southern Africa (White 2003: 55). White explains how westerners were captivated with the "primitiveness" of this physical appearance that was vastly different from the morphological features present among European groups. In 1810, this fascination led to the exhibition of Sattje Bartmann, also known as the "Hottentot Venus" who was brought to Europe in order to display her steatopygous buttocks for the public eye (White 2003: 55).

Racist attitudes are also evident through the terminology used to describe obesity in prehistoric figurines. The French archaeologist Edouard Piette identified two types of bodily figures and related them to racial types, where the "adipose" body types are representative of Southern African types and "svelte" figures represent Egyptian types (Conkey 1997: 190; White 2003: 54). Additionally, the first discovered figurine termed "Venus *impudique*/ immodest Venus" was slim, whereas afterwards the term "Venus" was satirically used to describe grotesquely obese figures such as the Hottentot Venus (Conkey 1997: 186; White 2003: 54). The sarcastic attitudes towards the bodies of

Hottentot women are also documented by the eighteenth-century traveler John Barrow, who observed a walking Hottentot woman as having "the most ridiculous appearance imaginable" (Barrow 1801: 281). The idea of Venus as a pejorative term is further evidenced by its inconsistent use in archaeological discoveries. In 1924, term "Venus" was not used at Eastern European site Kostienki I where figurines were being sequentially numbered (White 2003: 55). The usage of "Venus" is also problematic due to its implication of a female representation; however, many prehistoric figurines are androgynous and cannot be appropriately identified (Beck 2000: 203). The Venus term is a non-standard term that allows scholars to incorporate ideas from their Western background onto the analysis of these figurines. This terminology is not a form of reverence for classical art or a preoccupation with fertility; instead, it stems from the racist attitudes of Western European scholars of the twentieth century, and White argues that this term should be abandoned due to it being interpretively vacuous and inherently tainted (White 2003: 55). Language is a method used by colonialists to exert authority over their subjects; therefore, it is important to rid academia of a lexicon that was crafted by the subjugators and oppressors of non-Western populations (Warren 2012: 517).

It was also previously mentioned how researchers may refer to their contemporary ideas on enlarged breasts, bellies, and buttocks and create interpretations that may or may not have held the same meanings within the Neolithic societies that produced fat female figurines (Nakamura and Meskell 2009: 208). Scholars analyzing the theories surrounding fatness in iconography argue that concepts detailing pregnancy, maternity, and femininity of the female statuettes are based on the biased perspectives of male researchers who perceive these corporeal forms as adhering to their own contemporary Western ideas on female sexuality (McDermott 1996: 233-234; Beck 2000: 203; Klein 2001: 22). Prehistoric figurines are often regarded to be representative of goddess veneration and female related activities and rituals; however, these theories are embedded from Euro-American ideologies (Nakamura and Meskell 2009: 208). As demonstrated with King's analyses on prehistoric figurines, erotica theories perpetuate that idea that males were the sole creators and users of these figurines; additionally, this theory also promotes the idea that the naked female body is inherently sexual (Nelson 1990: 16). These theories reproduce masculinist perspectives regarding traditional western gender roles (Nelson 1990: 16). It is crucial that academics understand their biases in order to reduce the spread of false assumptions regarding the origins and functions of archaeological materials (Nesbitt 2001: 62).

Another major issue present in figurine analyses is the assumption that human images are direct reflections of individuals in prehistoric societies. Early researchers of obesity in prehistory often assumed that excessive fatness in iconographic sources are direct representations of Palaeolithic people (Haslam and Rigby 2010: 85; Kirchengast 2017: 36). Bailey's 2012 text "Figurines, Corporeality, and the Origins of the Gendered Body" elaborates how figurines are not direct reflections *of* prehistoric societies; rather, they are representations *for* (Bailey 2012: 245). This idea cautions researchers from perceiving these figurines as literal depictions of the prehistoric body. This assertion is also supported by Nakamura and Meskell's 2009 study of Çatalhöyük figurines. The authors note what while fatness is a physical trait that was depicted on the Neolithic figurines, an analysis of the site's bioarchaeological evidence indicates an absence of pathologies that are associated with excessive weight (Nakamura and Meskell 2009: 221).

While Bailey's text focuses on false assumptions regarding issues of gender and sexuality in prehistoric figurines, these false assumptions are also present when analyzing the visual representations of fat bodies in the archaeological record. An example includes the study of gendered fat, where excess adipose tissue on the human body is seen as either a male trait or a female trait depending on the culture and time period. Although fatness is engendered as a female trait in one society, it has an opposite meaning in another society. Moreover, eighteenth century colonial travelers observed fatness represented as a female trait among certain African tribes, but observers noticed an opposite representation in contemporaneous Asian societies where fatness was representative of male traits symbolizing strength and authority (Forth 2012: 221-222). Interpretations of prehistoric figurines are often generalized, and theories assuming the purpose of figurines from one site, region, or culture should not be considered a static and homogenous interpretation for figurines from different sites, regions, and cultures (Bailey 2012: 247). Disregarding the variation and contexts of these figurines allows researchers to develop generalizations and assumptions regarding the possible functions and meanings of the figurines (Nelson 1990: 14).

Body Idealization in Ancient Graeco-Roman Contexts

The contrasting theories regarding the creation of function of prehistoric could also be applicable to images of fat and obese bodies in Roman paintings and statues. Bradley's research focuses on the values and stereotypes that are present in the bodies depicted in Roman artwork ranging from the 7^{th}-4^{th} century BCE while also incorporating Roman copies of Hellenistic and Etruscan originals (Bradley 2011: 5). The concept of the idealized body is central in Graeco-Roman artwork, and the depictions of fleshy bodies provide insight on the societal discourses regarding health and fitness (Bradley 2011: 3-4).

While prehistoric figurines are enigmatic and lack concrete explanation for their origins, ancient Roman artwork is often accompanied by texts that provide supporting commentary regarding the purpose and meaning of artwork. Analysis of ancient medical literature provides evidence demonstrating the shifting discourses regarding fatness and health, and it is apparent that societies have become increasingly critical of the health benefits of fatness as time progressed (Bradley 2011: 10). Hippocrates, the father of Greek medicine, considered fatness as a disease; additionally, Hippocratic physicians describe the body as needing to be balanced (Klein 2001: 26; Papavramidou and Christopoulou-Aletra 2007: 115). Greek physician Galen also utilized the idea of balance to described a healthy body as moderately thin and fat (Papavramidou and Christopoulou-

Aletra 2007: 115). The gynecologist Soranus of Epheses believed that obesity was a chronic disease that required immediate treatment, and he also connected obesity with sterility and complications in birth (Medvei 1982: 43; Papavramidou and Christopoulou-Aletra 2007: 113). While these observations create negative perspectives on fatness through the process of medicalization, contrasting ideas on fat bodies are present among the artwork of ancient Rome.

Ideas on the ideal fertile female body can be observed through Roman sculptures of the female body, such as representations of Aphrodite and Venus (Figure 7.7) (Bradley 2011: 11). Statues such as the Venus Genetrix are sculpted in a way where the placement of the clothing was purposefully arranged in order to emphasize the female form (Bradley 2011: 13). Venus Genetrix means universal mother and is symbolic of procreation and fertility (Tinkle 1996: 80; Claridge et al. 1998: 150). Roman iconography also often depicts babies and infants as overly plump, and this is in response to the high infant mortality rates that affected Romans regardless of their wealth and social status (Bradley 2011: 14). The prevalence of obese Roman babies can be interpreted as the physical guidelines that were thought to increase the survival rates of infants; moreover, infants with greater amounts of bodyfat are thought to be advantageous in surviving past infanthood. Depictions which emphasize excess subcutaneous fat on the human body is a window into the creator's ideas of a body that is prepared for survival. The prevalence of fatter bodies in Roman art is interpreted to be the reverence of an idealized physical form. These images illustrate the physical standards that Roman society thought were associated with an increased lifespan and prosperity. Bradley states that the obese, fleshy bodies observed in Roman art are not reflective of the general population; instead, the use of fleshy and stout bodies was reserved for images of powerful Roman emperors and authority figures.

While ancient Roman societies incorporated fleshy bodies in the production of visual media, overweight and emaciated bodies are conspicuously absent from Greek art of the Classical period (Lee 2009: 157). This is unusual, as obese bodies were well known among ancient Greek societies (Bevegni and Adami 2003: 808). The rhetorician Claudius Aelian believed that severe obesity was true queerness, and he also reported his observations on the stateman Dionysius of Heraclea in Pontus during the fourth century BCE (Bevegni and Adami: 808). Aelian stated that Dionysius' obesity was the result of his gluttony and extravagance, and he connected this corporeal condition with shortness of breath (dyspnea) (Bevegni and Adami 2015: 808). Dionysius was also observably embarrassed of his physical state, and Aelian described how he hid himself from his audiences by hiding his entire body behind large objects so that only his head was visible to others (Bevegni and Adami 2015: 808; Bradley 2011: 25). Protruding bellies are a common element of caricature among ancient Greek societies, and overindulgence of food resulting in obesity was frequently satirized in comedy (Lee 2009: 157, 162).

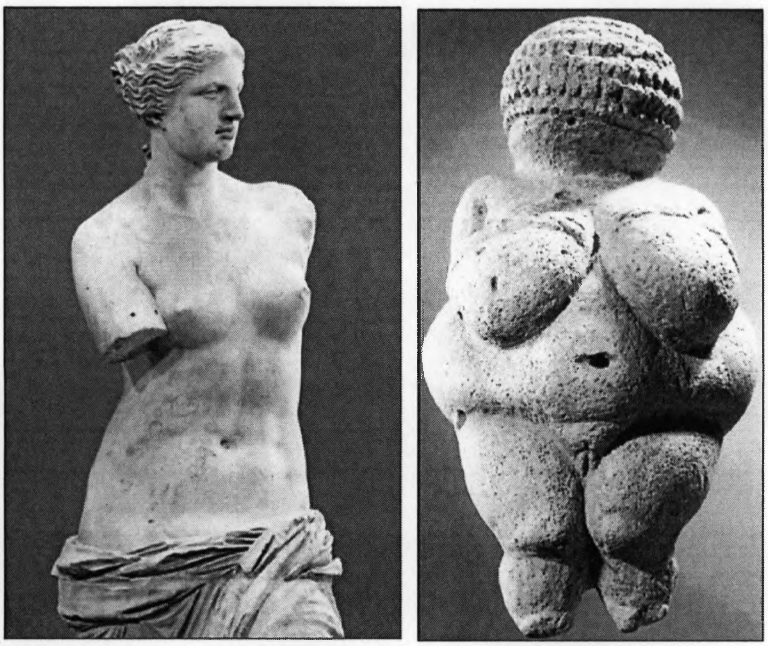


Figure 7.7. Venus de Milo [left] juxtaposed with the Woman of Willendorf [right] (Seshadri 2012: 135)

Figures such as Venus de Milo (Figure 7.7) were thought to be the standard for idealized beauty among Greek women. These ideals included rounded hips, a smooth stomach, and firm breasts (Kocjan and Giannini 1993: 23). The ideal male body was also tall and muscular, which is likely influenced by the emphasis of gymnasium activity throughout the Hellenistic period (Kousser 2005: 228). The gymnasium became the main cultural and educational institution of Grecian societies (Kousser 2005: 228). The gymnasium provided athletic, military, and academic training to the male elite, and those with adequate leisure time and financial resources might be able to attend the gymnasium as early as twelve (Kousser 2005: 245; Lee 2009: 165). A *diata* was a daily regimen of diet, exercise and bathing which were thought to be fundamental to the construction of elite identities and masculinity (Lee 2009: 156). This regimen promoted body modification among both males and females in order to achieve specific ideals regarding the hardness of a body; moreover, gymnasium exercise was considered to be an activity for elite males, whereas females were thought to achieve exercise through household chores (Lee 2009: 163, 165). These discourses prioritized the male Greek body, and the central role that gymnasium played in the lives of ancient Greeks would have promoted these discourses to be passed onto successive generations (Kousser 2005: 249).

Obese Etruscan Sarcophagi

Obesity is well known among Etruscan societies, as ancient Greeks and Romans would often ridicule the Etruscans for their obese bodies (Marvin 1917: 29; Klein 2001: 28; Edlund-Berry 2009: 292). The Latin poet Catullus noted that the Etruscan people were "short and thick set people" and referred to them as *obesus Etruscus* (Catullus 1893: 70; Scheffer 2009: 50). Etruscan tombs are known as the *Obesii*, and representations of obese Etruscans are commonly found as funerary effigies on sarcophagus lids. (Klein 2001: 28; Bradley 2011: 25). These funerary statues depict mature men with protruding stomachs that are interpreted as either social signifiers or realism of the human form (Figure 7.8) (Klein 2001: 26; Turfa 2016: 328). Turfa studied sarcophagi and urns of later fourth century and Hellenistic period, mainly from the region of Tarquinia. A screening of 800 effigies on sarcophagus and urn lids dated between fourth and first century BCE revealed only 80 effigies identified as overweight or obese males based on observations of rolls of fat and soft bodies (Turfa 2016: 328). An issue with Turfa's method is that the identification of obese bodies is entirely subjective without standardized measures such as WHR. Evidence of obesity is thought to be better interpreted from the stance of statues rather than body proportions, as being 50lbs overweight is associated with orthopedic stance of flat feet splayed to the sides (Turfa 2016: 325).

Figure 7.8. A Tarquinia sarcophagus dating to the first half of the second century BCE. The lid depicts an unknown overweight man (Turfa 2016: 332)

The depiction of fatness among Etruscan funerary effigies indicates an association between luxurious lifestyles and old age. Obesity was considered a sign of wealth among the Etruscans (Scheffer 2009: 50). It is assumed that since much of the ancient world was on the brink of starvation, overindulgence was a visible indicator of wealth and access to resources (Turfa 2016: 323). The Etruscans' fondness for food is also conveyed as frescoes found in tombs often depicted banquet scenes (Marvin 1917: 29). The prosperity of Etruria was established as early as the eighth century, but obesity related media seem to emerge much later (Turfa 2016: 323). This could indicate a shift in societal values that stimulated the production of obese visual representations.

Status and Longevity in Ancient Egypt

Contrasting ideas regarding body size and fatness among ancient Egyptian societies are observable through the bodily sculptures and imagery on stelas and reliefs. A general analysis on the ideals of pharaonic appearances denotes emphasis on slimness and youth (Teeter 2000: 150). Bodily depictions created during the Old Kingdom (Dynasties III-VI, 2686-2181 BCE) present individuals as slim and youthful beings in order to immortalize their ideal state for eternity (Teeter 2000: 165). Depictions of authoritative figures emphasize tall, muscled bodies; however, tall thin bodies were perceived as undesirable. Representations of emaciated men are rare due to its association with famine and suffering (Teeter 2000: 150). However, Old Kingdom ideas on body fatness shift when referring to age. While depictions of youthful persons emphasize slender bodies, depictions of middle-aged individuals emphasize a larger body size with thicker necks and larger breasts.

Fatness is also present among the statues of elite individuals. An individual of interest is Prince Hemiunu (Dynasty IV, 2750 BCE). Hemiunu was a senior official for the royal family and an architect who oversaw the construction of the Great Pyramid of Giza for King Khufu, and he also held various other positions as a religious official (Wilkinson 2007: 49). Hemiunu's fat body is exhibited as a life-size funerary limestone statue located within his immense tomb (Figure 7.9). Hemiunu's breasts and chest are sagging and his arms flabby, and researchers believe Hemiunu's statue is a realistic depiction of modern obesity (Teeter 2000: 150; Wilkinson 2007: 50; Finch 2011: 844). The excess fatness depicted in Hemiunu's statue is a pronounced deviation from the thin youthful figures present in Old Kingdom iconography, and this may be reflective of the elite's access to resources. Researchers believe that ancient elite Egyptians may have developed early atherosclerosis (a chronic disease linked to obesity) due to their increased intake of unsaturated fat from fattened geese and cattle, which are depicted in elite tomb paintings (Finch 2012: 20; Wann et al. 2015: 1031). The quality of fatness demonstrates the ability to indulge on resources whereas the rest of the population must survive through food rationing (Wilkinson 2007: 49). The obese portrayal of Hemiunu is not presented satirically; instead, Hemiunu's sculpture denotes a life of success, abundance, and status.

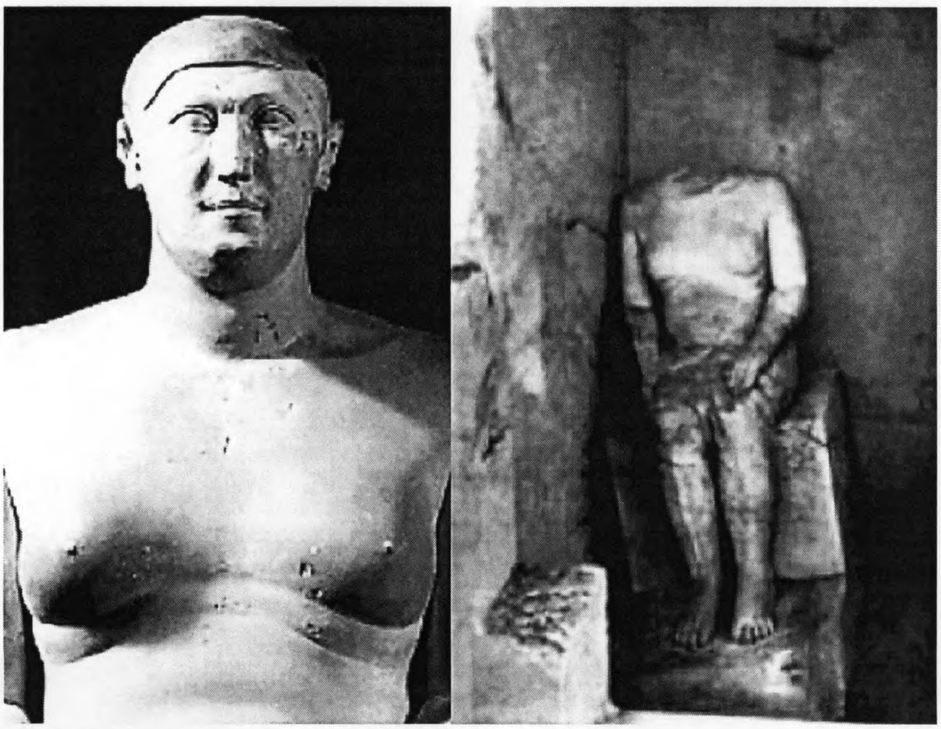


Figure 7.9. Left: The bust of Hemiunu depicting enlarged and saggy breasts
Right: The state of the statue as it was found in the tomb (Wann et al. 2015: 1035)

While the statue of Hemiunu provides an example of fatness among an elite individual, the stela of Neferhotep provides imagery of a corpulent person of minor social status. Stelas are stone slabs or columns with inscriptions usually commemorating a deceased person, and Neferhotep's stela dates to the Middle Kingdom (Dynasties XI-XII, 2050-1800 BCE). The crude workmanship indicates that it belonged to an individual of lower status, and this is also supported by the sculptor's signature of "the Carrier of Bricks, Nebsumenu" (Ward 1977: 63-64), which aligns with Neferhotep's position as a singer and harpist. The stela depicts Neferhotep seated on both feet before his food offering table, and he is leaning inward with both hands reaching out (Ward 1977: 63). This is an unusual position, as deceased subjects are usually postured with one hand extended toward the food offerings while the other hand is holding an object such as a lotus (Ward 1977: 63). It is believed that the artist of Neferhotep's stela intentionally portrayed him this way in order to emulate his life-long indulgences.

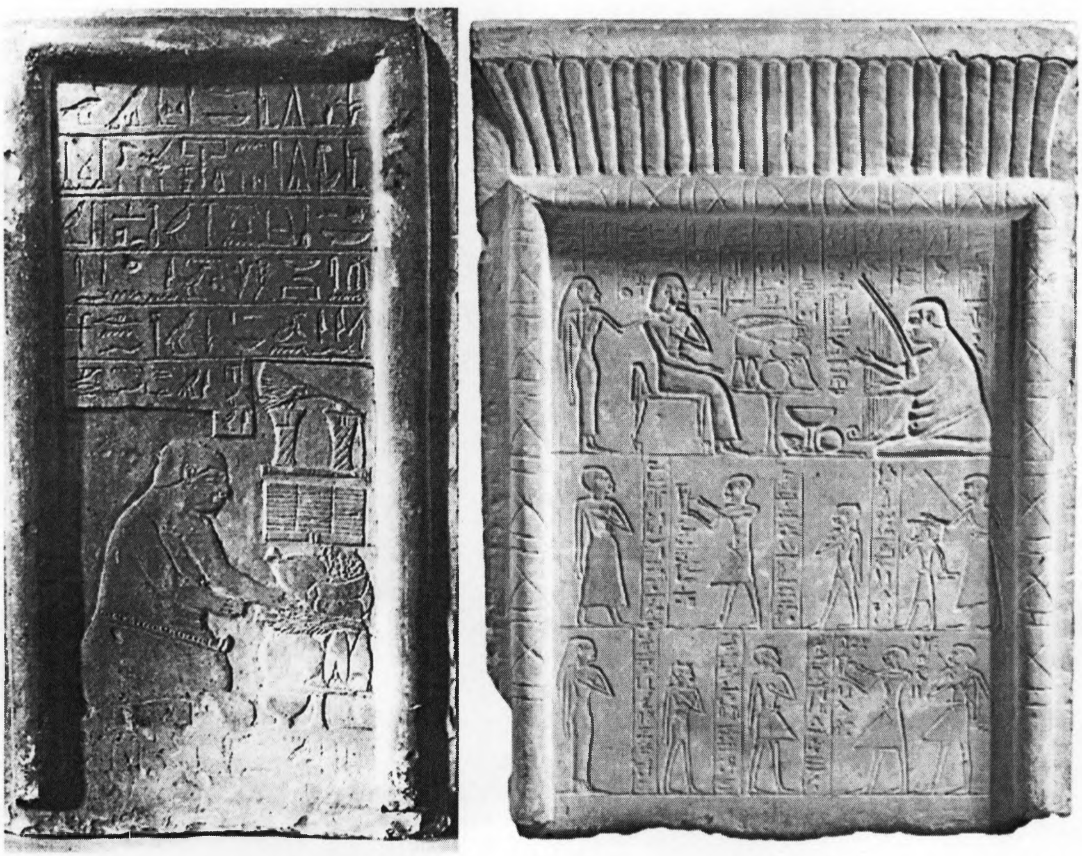


Figure 7.10. Left: Stela of Neferhotep created by Nebesumenu (Ward 1977: Plate IX)
Right: Neferhotep's appearance in Overseer of Prophets Iki's stela
(Oppenheim et al. 2015: 157)

Neferhotep also makes a special appearance on another stela playing the harp for his patrons, Overseer of Prophets Iki and his wife Nesankh (Figure 7.10) (Ward 1977: 64; Oppenheim et al. 2015: 157). The seated position in this stela is similar to the position displayed on Neferhotep's stela, which is unique in that he does not assume the traditional posture of a harpist. Instead on sitting on one foot with one knee raised, Neferhotep is depicted in a more comfortable position seated on both legs (Ward 1977: 64). Neferhotep's pose may be due to his physical inability to achieve the traditional harpist position. Images of Neferhotep contradict the societal standards for the ideal slender body, which may indicate shifting ideas regarding body fatness. Alternatively, the stelas of Neferhotep may also avoid body idealization in an attempt to accurately portray him as he was in life (Ward 1977: 65).

Mesoamerican Potbellies and "Fat Gods"

Visual representations of fat bodies emerged among early Mesoamerican societies as potbelly sculptures. Potbelly sculptures are found among the Guatemalan highlands across the Pacific slope, including two Maya lowland sites (Thompson and Valdez 2008: 13). These sculptures commonly depict cross-legged individuals with large stomachs, swollen facial features, and minimal bodily adornment (Thompson and Valdez 2008: 23; Halperin 2014: 100). The majority of these figurines are dated to the Late Formative period (500 BCE to 100 CE) and are usually in the form of small scale media (Thompson and Valdez 2008: 13; Halperin 2014: 100). Potbellies are typically sculpted from natural porphyritic basalt, but other types of stone and even ceramic have been used to create these figurines (Thompson and Valdez 2008: 18). These sculptures exist in a variety of forms including figures that are headless, head-only, clothed, unclothed, extended navel, absence of navel, and seated on pedestals (Thompson and Valdez 2008: 18). Potbellies also represent a variation of characters and categories of both natural and supernatural beings (Guernsey 2012: 121). A common concept used to explain these sculptures is the notion of a "Fat God", which is an enigmatic being that is present among the early cultures of Mesoamerica (Thompson and Valdez 2000: 23; Taube 2004: 156; Guernsey

2012: 124). Researchers often analyze Fat God figures by referring to the Classic Maya supernatural *sitz' winik* (glutton man), which is thought to have served as the satiric perceptions of gluttony and the role of performers (Guernsey 2012: 127; Taube 2004: 159).

Figure 7.11. Left: Late Formative Maya Fat God head from Monte Alto
Middle: Late Formative Maya Fat God potbelly sculpture from San Juan Sacatepequez
Right: Late Classic Maya Jaina Fat God holding a fan from Piña Chan
(Taube 2004: 159-160)

Some researchers hypothesize that Classic figures represent real fat men who held ceremonial positions (Taube 2004: 158). Classic period depictions of Fat God differ from Late Pre-Classic potbellies due to their elaborate costumes, and researchers hypothesize that these sculptures represent a performer denoting a trickster or ritual clown (Halperin 2014: 99, 102; Taube 2004: 159). This theory developed due to the similarities between the elaborate costume dress of potbelly Fat Gods with other supernatural beings, tricksters, and buffoons (Halperin 2014: 102). The performer theory is also supported by figures depicted with upraised arms, which is a common gesture for the action of dance among ancient Mesoamerican cultures; additionally, some sculptures also depict fans, which are common indicators of dance and performance in Maya iconography (Figure 7.11) (Taube 2004: 159). Fat men are also sometimes depicted as dancing duos (Halperin

2014: 104). Archaeologists have also discovered Fat God masks, which could have been used during ceremonial performances (Halperin 2014: 102). Some scholars hypothesize that the elaborate dress and masks are indicative of a deity, which is why these sculpted performers are referred to as Fat God (Thompson and Valdez 2008: 23; Lambert 2015: 109). Fat Gods as performing clown characters are thought to represent the personification of gluttony, which is a common topic for social commentary among Mesoamerican societies (Taube 2004: 159). Other topics include notions of excess, old age, disorder, hybridity, and transformation (Halperin 2014: 141).

While potbellies are commonly found at well-known ceremonial centers such as Kaminaljuyu, they are rarely discovered in primary contexts (Thompson and Valdez 2008: 24). Fat figurines are often discovered in elite households and regions (Halperin 2014: 105). While many potbellies are unclothed, a large number of these sculptures are depicted with pendants and collars that imply a high-status individual (Lambert 2015: 109). Fat God figures as status symbols is also symbolized among figurines seated on to of elevated pedestals, which may communicate social status and political authority (Guernsey 2012: 122; Lambert 2015: 105). Alternatively, potbelly sculptures are also connected to the concept of death. These figures are sometimes referred to as the supernatural *sitz' kimi* (glutton death) (Taube 2004: 159). It is proposed that Fat Gods are representations of dead ancestors, as the puffy, swollen, bloated characteristics are indicative of decomposition (Thompson and Valdez 2008: 23). These potbellies are also hypothesized to have served as false funerary bundles that were displayed in public areas to be used for ceremonies that connected deceased ancestors with the community (Lambert 2015: 109). Although interpretations of these figurines may vary, it is important to remember that the meanings of these figurines are not static and may have changed over time (Guernsey 2012: 129). This is supported by the appearance of elaborate dress and adornments present on Late Classic figures.

Obesity in Bernese Portraiture

The epidemiology of obesity may also be analyzed through the portraiture of a community over an extended period of time (Als et al. 2002: 1499). Als and colleagues focus on identifying the emergence and spread of goiter among the population of Berne, Switzerland. Goiter is characterized by excessive growth and transformation of thyroid tissue, which results in a visibly enlarged thyroid gland (Hegedüs 2003: 102). Although Als and colleagues focus their study on goiter, studies have linked the expression of obesity with the presence of goiter. Obesity is hypothesized to be a phenotypic presentation of goiter, as higher goiter prevalence and increased thyroid volume is observed among obese women (Eray et al. 2010: 44).

Figure 7.12. Portrait of Swiss novelist Jeremias Gotthelf (1797-1854) with concealed goiter (Als et al. 2002: 1500)

Als and colleagues' sample consisted of 5,493 portraits dated between the Renaissance period to the twentieth century (Als et al. 2002: 1499). The authors excluded paintings that lacked sociodemographic data, depicted multiple subjects, or were miniature/shadow portraits. The number of paintings was reduced to 3,615, where 2,989 of the subjects were identifiable while 626 were unknown subjects (Als et al. 2002: 1499). The authors identified a trend in which overweight bodies were more common in identified men than in identified women (44% of overweight men versus 30% of overweight women); however, this differentiation was smaller among the unidentified group (Als et al. 2002: 1499). Excess weight was also correlated with age, as goiter affliction was higher among individuals over 40 years old compared to younger individuals in all centuries combined (Als et al. 2002: 1499). The authors concluded that while overweight bodies may seem prevalent within the sample, artistic idealization may over-emphasize the corporeality of these subjects (Als et al. 2002: 1501). Additionally, people depicted in portraits may not be representative of the entire population, as it is likely that these portraits favored the representation of wealthy and healthy subjects compared to the majority of the population (Als et al. 2002: 1501). While the subjects in Bernese portraiture is skewed towards high status individuals, this analysis links the concept of excess fat and obese bodies with social status and gender, as indicated in the contrasting prevalence among known males and females.

Summary

An archaeological analysis of obesity will benefit from analyzing visual representations, yet researchers must be cautious when interpreting these materials. Visual representations of obesity in prehistoric societies often occur in the form of anthropomorphic figurines that date back to the Upper Palaeolithic and Neolithic. These figurines lack explicit explanation; moreover, there will never exist written records detailing the exact purpose of these figurines depicting fat-bodied humans. Therefore, researchers have developed various theories pertaining to the origins and purpose of fatness in these figurines. Alternatively, visual representations of obesity in ancient societies are sometimes accompanied with historical documentation that details the societal attitudes towards fat and obese bodies. However, the concepts of fatness and obesity in ancient societal discourses are vastly different from modern discourses on fatness and body image. The existing studies also contain problematic issues regarding the colonial and male biases that permeate archaeological discourses on obesity. It is important to acknowledge these biases in order to prevent future obesity scholars from creating generalized and biased assumptions on obesity and the female body in the archaeological record.

Conclusions: Obesity in North American Discourse—Past, Present, and Future

This thesis sought to analyze how shifting societal values and discourses influenced the stigmatization of body fatness through the processes of moralization and medicalization. The archaeological analysis of obesity first requires the identification of this physical condition among archaeological materials. As stated in chapter 2, obesity is a highly-medicalized concept which relies on the measure of adipose tissue for diagnosis. The analysis of obesity and body fatness is hindered due to the lack of preservation of soft tissues in the archaeological record. An analysis of the osteological responses to obesity allows researchers to identify the effects of excess body weight on load-bearing limbs, even though linear regression analysis fails to recognize physical extremes such as obesity and emaciation. However, the estimation of body mass and stature is still useful in identifying the variation in body size between and within skeletal populations.

While the direct approach of body mass estimation has its limitations in the study of obesity in archaeology, an indirect analysis of skeletal remains will still provide data regarding pathologies associated with obesity and excess weight. The clinical analysis on DISH, HFI, and gout supports the association between these pathologies and modern obesity. Analysis of these pathologies among European populations indicates strong associations between age, sex, and sometimes social status; however, the presence of these pathologies is rare among North American skeletal samples. Two cases of DISH have been discovered at two pre-Columbian sites in Tennessee; however, these unique cases lack evidence supporting increased food intake, social status, and increased longevity among this population. Future studies should focus on estimating body mass and stature within the Late Mississippian Tennessee skeletal population studied by Smith and colleagues. The DISH-afflicted Cox Burial 170 is determined to be reasonably complete; therefore, estimation of body mass and stature should provide a general impression of the variation in body sizes of the DISH-afflicted specimens in contrast to the rest of the Pre-Columbian Tennessee population. An analysis of BME and stature within this sample would also provide supplementary information on the influence that bio-cultural environment may have had on the presence of DISH within this population.

A crucial study indicating a link between status, age, and sex is Mulhern and colleagues' analysis of HFI frequency among the population of Pueblo Bonito in Chaco Canyon, New Mexico. This study identified high frequencies of HFI among adult skeletal samples, and the majority of affected remains were identified as female. Additionally, previous studies established Pueblo Bonito as a high status residential area and internment site. This study analyzes the only HFI affected skeletal sample in North America; however, the association between HFI and obesity is still unclear and caution must be taken when utilizing HFI and other associated pathology studies in order to study obesity. The relationship between obesity and HFI may benefit from future BME and stature analysis of the post-cranial remains in the Pueblo Bonito sample. BME studies could also reveal the degree in body size variation in relation to the severity of HFI. However, an issue with BME and pathological studies in general is that societal attitudes towards fat and obese bodies are unclear unless the skeletal remains are accompanied by supplementary sources that elaborate on these attitudes and discourses.

While the analysis of skeletal pathologies attempts to identify possible fat and obese bodies in archaeological contexts, the analysis of visual representations provides further information on prehistoric and ancient perceptions and values placed on body fatness. However, a limitation in utilizing archaeological representations of fat bodies is that the highly-medicalized concept of obesity may not be applicable in these contexts. Researchers such as King, Guthrie, and Tripp and colleagues have attempted to identify waist-to-hip ratios among Palaeolithic and Neolithic figurines, but these studies emphasize their focus on measuring the physical properties of the body. Moreover, the intended meanings for these figurines should not be assumed based on modern quantitative measurements that would not have held the same meanings in prehistoric contexts. Overall, visual representations of fat and obese bodies have been identified in

European, African, and Mesoamerican contexts, yet the North American archaeological record severely lacks iconographic information on excess body fatness. Future studies analyzing excess body weight in North American contexts should focus on body mass estimation techniques and the presence of skeletal pathologies associated with body weight.

It is important for academic scholars to recognize their biases in order to prevent contemporary ideas surrounding body aesthetics and gender from influencing their analysis of prehistoric and ancient materials. As mentioned in chapter 7, early nineteenth century observations on excess fatness and fatness rituals often carry negative connotations and racist undertones in describing these bodies due to their deviation from European norms. Within archaeological research, non-standard terms such as "Venus" have sarcastic origins yet are still used in describing prehistoric figurines. Western ideas on female breasts, stomachs, and buttocks are highly sexualized, and it is necessary for researchers to acknowledge that these exaggerated figurine body parts may not have held the same values in Palaeolithic and Neolithic societies. Another common academic assumption is on the gendering of figurines, as excessively fat figurines are often identified as female due to the exaggeration of the breasts and buttocks. However, gender should not be assumed based on these vague standards. Additionally, researchers must refrain from assuming that Palaeolithic and Neolithic anthropomorphic figurines are direct reflections of the populations. These academic assumptions on the functions of prehistoric figurines serve as an example of how societies from different cultural contexts vary in ascribing specific values to a physical attribute. The stigmatization of fatness changes its meaning with time; moreover, fatness may hold different social values in the future depending on the shifts in societal values and discourse.

As presented in the North American history of obesity in chapter 1, weight stigma and bias is powerful and permeates societal discourses on fat and obese bodies. Although this thesis identifies a lack of information on obesity in North American contexts, the archaeological analysis of fat and obese bodies in other global regions allows for further insight on the dynamic characteristics of obesity discourse. Attitudes regarding fat and thin bodies are constantly shifting based on changes in societal values, and the archaeology of obesity provides a greater understanding of the biological, environmental, and social influences that aid in the construction of these societal ideologies. Archaeological obesity research demonstrates the shifting nature of societal discourses regarding fatness and obesity over time, and the social values ascribed to fat and obese bodies will continue to shift into the future.

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