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Abstract

This study compares two US BMI data sets, one from the 1800s and the other from the early 2000s, to determine how black and white male obesity rates varied between 1800 and 2000. The proportion of individuals who were obese rather than overweight is responsible much of the increase in obesity. Because of their physical activity and close proximity to nutritious diets, farmers had greater BMI values than workers in other occupations; however, since the 19th century, physically less active white-collar and skilled workers have become more obese. Northeastern obesity rates are lower than from elsewhere within the US, while Midwestern BMIs increased and western BMIs decreased.

JEL-Code: I100, I120, J110, J150, N300.

Keywords: BMIs, US obesity epidemic, long-term health, obesity by race.

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I appreciate comments from Gary Taubes and John Komlos.

1. Introduction

Increased obesity rates have emerged in every developed country and in a number of developing ones. In 2008, there were 1.5 billion adults over the age of 20 that were overweight; 200 million men and 300 million women were obese (World Health Organization, 2009; Grossman and Macon, 2011, p. 1). The United States is at the forefront of this epidemic, and in 2007-2008, 68 percent of adult men were overweight (BMI$\geq$25), while 32 percent were obese (BMI$\geq$30). The obesity trend may be the most pronounced for females (Himes, 2011, p. 40; Flegal, et al., 2010; Flegal, et al., 2012), and sixty four percent of adult women are overweight, while 36 percent are obese (Flegal et al. 2012; Himes, 2011, p. 40). The trend is concerning because there are significant health costs associated with obesity, and increasing obesity rates occurred too quickly to be explained only by a change in genetic variation (Roberto and Brownell, 2011, p. 588; Catenacci, et al., 2011, p. 814; Finkelstein and Yang, 2011; Atlas, 2011, pp. 103-105) but were probably influenced by behavior and the environment (Roberto and Brownwell, 2011, p. 588; Gregory and Ruhm, 2011, p. 321; Thompson and Gorden-Larsen, 2011, p. 69). However, important obesity questions remain unanswered. For example, while average BMIs have increased, little is known about the long-term shift in BMI distributions and if the change in obesity has been the same across region, socioeconomic status, and ethnicity. This study, therefore, considers which part of the BMI distribution is responsible for the increase in obesity, how BMIs were related to changes in socioeconomic status between 1800 and the present, and how obesity is related to residence and the physical environment.

There are multiple ways to measure obesity, and although it is imperfect, the body mass index (BMI) is the primary means to measure obesity's prevalence (Must and Evans, 2011, p. 11). BMI is weight in kilograms divided by height in meters squared and reflects the net current balance between calories consumed and energy expended for work and to fend off disease (Fogel, 1994, p. 375; Strauss and Thomas, 1998).[1] Before the modern obesity epidemic, average BMIs increased when net nutrition improved and decreased when it deteriorated. Interpreting BMI variation is also more problematic than understanding other biological measurements because BMI variation reflects early life conditions (Ravelli et al, 1976; Pettit et al. 1983; Forsen et al. 2000). For example, if an individual is poorly nourished as a youth, their statures may be short, their frames possibly smaller, and their basal metabolic rates will be lower. Improved nutrition in later life, therefore, results in greater BMI values. On the other hand, a well-nourished youth may develop taller frames, have greater basal metabolic rates, and have lower BMIs in later-life (Costa, 2004; Baum and Ruhm, 2009; Carson, 2009a; Floud et al., 2011, pp. 337-338; Thompson and Gorden-Larsen, 2011, p. 72; Carson, 2012).

Historical BMIs provide important insight on the evolution of health during economic development, and primary diseases associated with high BMIs include diabetes mellitus, hypertension, dyslipidemia, coronary heart disease, stroke, gall bladder disease, osteoarthritis, and respiratory diseases (Must et al., 1999, pp. 1525-1527; Atlas, 2011, pp. 103-105). Waaler (1984) and Koch (2011) find that low BMIs are inversely related with life expectancy, and diseases associated with low BMI mortality include malnutrition, tuberculosis, and other infectious diseases (Crimmens and Condran, 1983, p. 33). Costa (1993) applies Waaler's results

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[1] $BMI = \frac{Weight\ in\ Kilograms}{(Height\ in\ Meters)^2} = \left(\frac{Weight\ in\ Pounds}{((Heights\ in\ Inches))^2}\right) \times 703$

to a historical population and finds the relationship with mortality applies to a historical population, while Jee et al. (2006, pp. 780 and 784-785) find the relationship is stable across racial groups.[2] Costa (2004) and Carson (2009b and 2012) demonstrate that 19th century blacks had greater BMI values than whites. Costa also finds that BMIs increased by about 13 percent between 1860 and 1950. Cutler, Glaezer, and Shapiro (2003) find that US BMIs increased since the beginning of the 20th century, and the majority of increased obesity rates over the last 25 years occurred because people consume more calories, not because they are physically inactive. On the other hand, Lackdawala and Phillipson (2002, p. 25) find that about 60 percent of increased obesity rates are due to decreased physical activity and energy expended during household activities.[3] Moreover, the most vexing modern relationship with high BMIs is adult onset diabetes, and excess weight increases blood pressure and insulin levels, elevates low density lipoprotein cholesterol, while lowering high density lipoprotein cholesterol (Bray, 2004).[4] Therefore, increasing modern obesity is related with a broad set of health measurements, and these obesity related conditions have become more prominent with the modern obesity epidemic.

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[2] Henderson (2005, p. 361) suggests there cuts off risks may be different across ethnicities but does not demonstrate mortality risks have increased.

[3] This biological interpretation of an excess of net calories relies on the long-accepted interpretation that obesity results when insufficient calories are expended relative to those consumed. This interpretation suggests that calories are equal between nutrients: carbohydrates, proteins, and fat. However, an alternative interpretation is that obesity results because of hormonal imbalances that result when too many carbohydrates are consumed. Excess carbohydrates stimulate insulin production, which leads to excess weight gains (Taubes, 2007; Taubes, 2010).

[4] Health improves for obese individuals, and even modest weight loss of five to ten percent include decreased blood pressure, and cholesterol, and a 25 percent reduction in mortality risk of adult-onset diabetes (Vidal, 2002; Cawley and Price, 2011, p. 92).

It is against this backdrop that this study considers three paths of inquiry into the development of US obesity over the last 200 years. First, how have obesity rates changed overtime, and which part of the BMI distribution is responsible for the increase? The question is important, because BMIs may have changed at unequal rates across the distribution. Between 1800 and 2000, the proportion of individuals in the normal category decreased, the proportion in the overweight category increased moderately, while those in the obese category increased considerably. Second, how have BMIs changed by socioeconomic status? Because of their physical activity and close proximity to nutritious diets, farmers have heavier BMIs than workers in other occupations; however, since the 19th century, physically less active white-collar and skilled workers have become more overweight and obese than farmers and unskilled workers. Third, how have BMIs and obesity changed within the US by residence? Northeastern obesity began and remained low relative to elsewhere within the US, while Midwestern obesity increased, and Western obesity decreased.

II. Nineteenth Century Prison Data and the National Health Inventory Survey

Long-term studies are instrumental in understanding obesity's development, and because 19th century health studies that controlled for various selection biases were not collected, a randomized data source that extends over 200 years is not available. To make such a comparison requires grafting multiple data sets from various sources that had different selection criterion. Comparing two data sets with different selection processes is also made with caution because differences are due to either variation in sample characteristics or differences in selection criterion. However, comparing historical data sets with modern samples is not without precedent. For example, Henderson (2005) compares 19th century white Civil War soldiers with modern NHANES records to contrast modern with historical BMIs and demonstrates that obesity thresholds associated with a change in mortality risk increased between the 19th and 20th centuries. Komlos and Brabec (2010) use an NHANES sample by birth year to infer that post-industrialized weight gain between 1880 and 1980 was a gradual process and began earlier than supposed. Floud et al. (2011, pp. 344-362) use Civil War military records and National Health Interview Survey (NHIS) data to consider the relationship between BMI, health, and labor market outcomes and find that average BMIs have increased since 1870 (Floud et al., 2011, p. 336). The current study uses late 19th and early 20th century prison and modern NHIS records to consider changes in US BMI patterns from the beginning of the 19th century to the present.

Nineteenth Century US Prison Data

The two most common sources of historical BMI measurements are military and prison records. BMIs are inversely related with height (Herbert et al., 1993, p. 1438; Fogel et al, 1978, p. 85; Sokoloff and Vilaflor, 1982, p. 457, Figure 1), and taller statures are associated with lower BMIs. Minimum height requirements in military samples truncate shorter statures, which underestimates BMI values because only individuals with taller statures and lower BMI values remain in military samples. Fortunately, prison records do not suffer from this truncation bias observed in military samples. However, interpreting prison records is difficult because poorer individuals may have been more likely to resort to crime out of privation. Using prison records, therefore, assumes that any selection bias that reduces external validity with the general public is smaller than the truncation bias present in military records. Nevertheless, using all prison observations remedies this concern because both lower and middle class individuals are included in prison samples.

Table 1, Nineteenth Century and Modern BMI Samples

	Historical		*Modern*	
	N	Percent	N	Percent
Ages				
Teens	15,248	11.53	1,838	2.49
Twenties	72,546	54.85	12,250	16.57
Thirties	27,190	20.56	13,334	18.03
Forties	11,021	8.33	14,222	19.23
Fifties	4,506	3.41	13,202	17.85
Sixties	1,446	1.09	9,964	13.47
Seventies	299	.23	9,135	12.35
Residence				
Northeast	29,604	22.38	11,854	16.03
Midwest	11,999	9.07	17,321	23.42
South	79,964	60.46	27,981	38.84
West	10,689	8.08	16,789	22.70
Occupations				
White-Collar	8,622	6.52	21,064	24.49
Skilled	21,059	15.92	26,004	35.17
Farmer	12,909	9.76	813	1.10
Unskilled	66,163	50.03	24,254	32.80
No Occupation	23,503	17.77	1,810	2.45
Ethnic				
Black	61,898	46.80	11,113	15.03
White	70,358	53.20	62,832	84.97
Total	132,256	100.00	73,945	100.00

Source: National Health Interview Survey and Carson (2009).

The prison data used here is part of a large 19th century prison sample (Table 1).[5] Most African-Americans were imprisoned in the Deep South or Border States—Kentucky, Missouri, and Texas. Most whites were imprisoned in Missouri and Texas. Northern whites were from Pennsylvania and the Far West. Physical descriptions were recorded by prison enumerators at the time of incarceration as a means of identification, therefore, reflect pre-incarceration

[5] All state prison repositories were contacted and available records were acquired and entered into a master data set. These prison records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania, Texas, and Washington (Table 1).

conditions. Between 1840 and 1920, prison officials routinely recorded the dates inmates were received, age, complexion, nativity, height, weight, pre-incarceration occupation, and crime; all records with these variables are included in this study. Because accurate recordings had legal implications for identification in the event that inmates escaped and were later recaptured, there was care in recording inmate height and weight values. Arrests and prosecutions across states may have resulted in various selection biases that may affect the results of this analysis. However, black and white height, weight, and BMI variations across US prisons are consistent with other historical health studies (Cuff, 1994; Coclanis and Komlos, 1995; Costa, 2004; Floud et al., 2011).

While there have always been many ethnicities within the United States, the two most prominent ethnicities that have received attention over its 200 year history are from Africa and Europe ancestry. As a result, the prevalence of white and black male obesity trends are the focus of this study. Inmate enumerators were thorough when recording inmate complexion and pre-incarceration occupation. For example, enumerators recorded inmates' race in a complexion category, and African-Americans were recorded as black, light-black, dark-black, and various shades of mulatto (Komlos and Coclanis, 1997). Enumerators recorded white complexions as light, medium, dark, and fair. The white inmate complexion classification is supported by European immigrant complexions, which were always of fair complexion and were also recorded as light, medium, and dark. While mulatto inmates possessed genetic traits from both European and African ancestry, they were treated as blacks in the 19th century US and when comparing whites to blacks, mulattos are grouped here with blacks.

Enumerators recorded a broad continuum of occupations, which are classified here into four categories: merchants and high skilled workers are white-collar workers; light manufacturing, craft workers, and carpenters are skilled workers; workers in the agricultural sector are farmers; laborers and miners are unskilled workers (Tanner, 1977, p. 346; Laudurie, 1979; Margo and Steckel, 1992; p. 520). Unfortunately, inmate enumerators did not always distinguish between farm and common laborers. Since common laborers probably encountered less favorable environmental conditions during childhood and adolescence, this probably overestimates the biological benefits of being a common laborer and underestimates the advantages of being a farm laborer (Carson, 2013, p. 62). Because there are too few observations, females are excluded from the analysis.

Table 2, Nineteenth Century and Modern Sample Composition by Race, Demographics, and Socioeconomic Status

	Black		*White*	
	N	Percent	N	Percent
Ages				
Teens	8,598	11.78	8,488	6.37
Twenties	37,893	51.90	46,903	35.22
Thirties	13,035	17.85	27,489	20.64
Forties	6,451	8.84	18,792	14.11
Fifties	3,789	5.19	13,919	10.45
Sixties	1,948	2.67	9,462	7.10
Seventies	1,297	1.78	8,137	6.11
Residence				
Northeast	9,498	13.01	31,960	24.00
Midwest	6,147	8.42	23,173	17.40
South	55,110	75.48	52,835	39.67
West	2,256	3.09	25,222	18.94
Occupations				
White-Collar	3,803	5.21	25,883	19.43
Skilled	8,391	11.49	38,672	29.04
Farmer	5,990	8.20	7,732	5.81
Unskilled	40,518	55.50	49,899	37.46
No Occupation	14,309	19.60	11,004	8.26
Era				
Historical	61,898	84.78	70,358	52.83
Modern	11,113	15.22	62,832	47.17
Total	73,011	100.00	133,190	100.00

Source: See Table 1.

Black and white inmates' BMI proportions by age, birth decade, occupations, and nativity are presented in Table 2. Although average BMIs are included, they are not reliable because of possible compositional effects, which are accounted for in the regression models in the next section. Whites were a larger portion of the prison population than blacks; 53 percent of the US prison population was white. Age percentages demonstrate that black inmates were incarcerated at younger ages, and whites were incarcerated at older ages. During the early 19th

century, blacks were less likely to be incarcerated; however, with passage of the 13th Amendment, slave owners no longer had claims on black labor, and free blacks who broke the law were turned over to state penal systems to pay for their crimes.[6] Whites within 19th century US prisons were more likely than blacks to be white-collar, skilled workers, and farmers. Blacks were more likely to be unskilled.

National Health Interview Survey

For modern US populations, the National Health Interview Survey (NHIS) is a comprehensive late 20th and early 21st century data set collected from the National Center for Health Statistics (NHCS) and provides nationally representative estimates for a wide range of health conditions.[7] Moreover, the NHIS is useful in comparing historical obesity rates because it documents height and weight, therefore, BMI. The NHIS also includes age, occupations, and residence, which are absent from other modern BMI samples. NHIS height and weight values are self-reported, and both are restricted in the combined prison and NHIS samples to height above 59 and below 76 inches; weights are restricted to between 99 and 285 pounds (Kelly, 2011, p. 195). Ages in both the prison records and NHIS samples are for 18 years and older. Like the prison data, occupations within the NHIS are classified as white-collar, skilled, farmers, unskilled, and without specified occupations, and comparing occupational distributions between prison data and the NHIS is made with the recognition that occupations have changed since the mid-19th century (Rosenbloom, 2002, p. 88). Nevertheless, classifications for both the prison data and NHIS maintain the occupational classifications from highest to lowest skills. Residence

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[6] Southern law evolved to favor plantation law, which generally allowed slave owners to recover slave labor on plantations while slaves were punished (Komlos and Coclanis, 1997, p. 436; Wahl, 1996, 1997; Friedman, 1993).

[7] http://www.cdc.gov/nchs/nhis.htm. The Center for Disease Control’s National Center for Health Statistics.

in the prison and NHIS are classified as Northeast, Midwest, South, and West, and these regional classifications are used because they are consistent with the regional categories used by the NHIS.

Separating the sample into historical and modern periods illustrates that criminals were younger (Table 1). This reflects greater youth criminal activity and the modern aging of the US population (Hirschi and Gottfredson, 1983). Residence in the historical sample was more likely from the Northeast and South, while residence for the modern sample is more likely from the Mid and Far West. Between the 19th and 21st centuries, occupations became considerably more skilled (Rosenbloom, 2000, p. 88). Comparing the combined data sets by race and overtime demonstrates that blacks are younger, reside in the South, and are less skilled than whites. The modern sample is older, resides in the Midwest and West, and is more skilled.

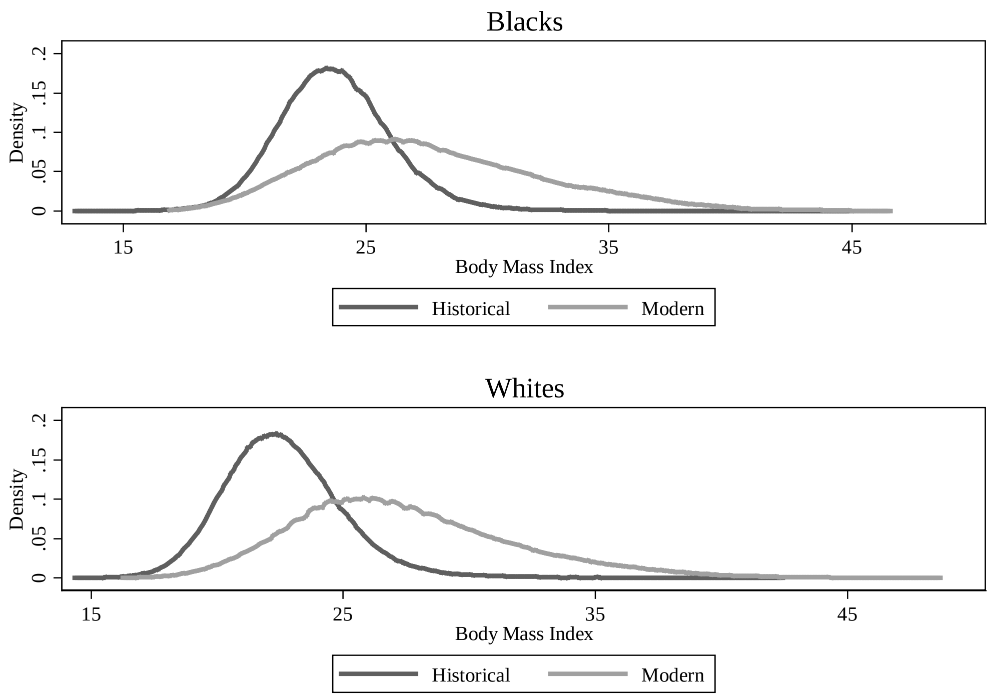
III. Nineteenth Century Prisoner and Modern US Comparison

Comparing average BMIs and the shape of the distribution indicates much about net nutritional conditions. Average adult black historical BMI was 23.76, and modern average black BMIs is 27.62. Average historical white BMI was 22.63, and modern average white BMI is 27.43, indicating that modern average black and white BMIs have increased by 16.25 and 21.21 percent, respectively.[8] Moreover, these increases are likely underestimates because modern self-reported heights are overestimated, and weights are underestimated (Palta, 1982; Rowland, 1990). In sum, black BMIs were historically greater than for whites; nevertheless, modern black and white BMIs have increased, and there is currently little difference between black and white

[8] The historical black BMI standard deviation is 2.35; the modern black BMI standard deviation is 4.65. The historical white standard deviation is 2.39; the modern white standard deviation is 4.33.

BMIs and obesity (Figure 1; Himes, 2011, p. 40; Flegal et al., 1998; Flegal et al. 2010 and 2012).

Figure 1, Nineteenth Century and Modern Black and White BMI distributions



Source: See Table 1.

Using the World Health Organization's BMI classification for modern standards, BMIs are classified into modern WHO BMI categories. BMIs less than 18.50 are underweight; BMIs between 18.50 and 24.99 are normal; BMIs between 25.00 and 29.99 are overweight; BMIs greater than 30.00 are obese (World Health Organization, 2006).

Table 3, Nineteenth Century and Modern BMI Categories by Race and Occupations

	Historical				*Modern*			
	Black		White		Black		White	
	N	Percent	N	Percent	N	Percent	N	Percent
Total								
Underweight	421	.78	1,675	2.38	52	.47	194	.31
Normal	44,350	71.65	58,605	83.60	3,339	30.05	18,725	29.80
Overweight	16,396	26.49	9,477	13.47	4,634	41.10	28,474	45.32
Obese	671	1.08	601	.85	3,088	27.79	15,439	24.57
	61,898	100.00	70,358	100.00	11,113	100.00	62,832	100.00
Occupations								
White-Collar								
Underweight	13	.77	251	3.62	14	.66	43	.23
Normal	1,269	75.00	5,545	80.01	558	26.43	5,729	30.23
Overweight	384	22.70	1,007	14.53	954	45.19	8,838	46.63
Obese	26	1.54	127	1.83	585	27.71	4,343	22.91
	1,692	100.00	6,930	100.00	2,111	100.00	18,953	100.00
Skilled								
Underweight	44	.89	352	2.19	13	.38	63	.28
Normal	3,577	71.97	13,385	83.29	1,049	30.66	6,614	29.29
Overweight	1,263	25.41	2,205	13.71	1,416	41.39	10,357	45.86
Obese	86	1.73	147	.91	943	27.57	5,549	24.57
	4,970	100.00	16,089	100.00	3,421	100.00	22,583	100.00
Farmer								
Underweight	35	.59	143	2.04			5	.68
Normal	4,126	69.85	5,794	82.75	31	37.35	207	28.36
Overweight	1,676	28.37	992	14.17	31	37.37	340	46.58
Obese	70	1.19	73	1.04	21	35.30	178	24.38
	5,907	100.00	7,002	100.00	83	100.00	730	100.00
Unskilled								
Underweight	287	.81	684	2.23	18	.36	70	.36
Normal	25,806	72.68	25,670	83.74	1,490	29.73	5,575	28.97
Overweight	9,063	25.52	4,102	13.28	2,056	41.03	8,499	44.17
Obese	351	.99	200	.65	1,447	28.88	5,099	26.50
	35,507	100.00	30,656	100.00	5,011	100.00	19,243	100.00
No Occupation								
Underweight	102	.74	245	2.53	7	1.44	13	.98
Normal	9,572	69.25	8,211	84.82	211	43.33	600	45.35
Overweight	4,010	29.01	1,171	12.10	177	36.34	440	33.26
Obese	138	1.00	54	.56	92	18.99	270	20.41
	13,822	100.00	9,681	100.00	487	100.00	1,323	100.00

Source: See Table 1.

Between 1800 and 2000, modern adult BMIs increased relative to historical values (Carson, 2009b; Carson, 2012; Flegal et al. 2012, pp. 493-494; Ogden et al. 2012, p. 486); however, it is less clear which part of the normal, overweight, and obese categories are responsible for the increase. Modern obesity may have increased because the entire distribution shifted to the right, or modern obesity may have increased and become negatively skewed because there were more people in the overweight and obese categories. Compared to the 19th century, modern blacks and whites in the normal category have decreased by 58 and 64 percent, respectively (Table 3). However, their modern counterparts in the overweight category have increased by 55 and 237 percent. The most notable finding is that modern black and white males are 2,473 and 2,791 percent more likely to be obese than the 19th century working class. Therefore, black and white BMIs have increased, there has been a decrease in the share of blacks and whites in the normal BMI category, and significant increases in the share that are obese.

IV. Comparative Effects of Demographics, Socioeconomics, and Residence with US BMIs

The timing and extent of BMI variation reflects the relationship between diet and physical activity; it also reflects socioeconomic conditions, residence, and observation period (McLaren, 2007; Litaker, Sudaro, and Colabianchi, 2004; Carson, 2012). We test which of these variables are associated with historic and modern BMI variation. To start, the BMI of the i^{th} individual is assumed to be related to demographics, residential status, socioeconomic characteristics, and observation period.

$$BMI_i = \alpha + \sum_{r=1}^{2} \beta_r Race_i + \beta_c Centimeters_i + \sum_{a=18}^{70s} \beta_a Age_i + \sum_{p=1}^{4} \beta_p Residence_i$$

$$+ \sum_{l=1}^{5} \beta_l \text{Occupations}_i + \sum_{t=1840}^{2000} \beta_t \text{Observation Period}_i + \varepsilon_i$$

A complexion dummy variable is included to account for the relationship between BMIs and skin complexion. A continuous height variable in centimeters is included to account for the inverse relationship between BMI and height. One-year age dummy variables are included for ages between 18 and 22, and older decade dummy variables are included for ages between the 30s through 70s. Residence dummy variables account for the relationship between BMI and environmental conditions at the time of measurement. To account for BMI variation by occupations and socioeconomic status, dummy variables are included for white-collar, skilled, agricultural, and unskilled occupations. Observation period dummy variables are included to measure how BMIs varied with current net nutritional conditions over time.

To better isolate how BMIs differed by race and socioeconomic conditions, Table 4's Model 1 presents estimates for the combined prison and NHIS data set. Model 2 presents estimates for the combined historical and modern black sample, and model 3 does the same for whites. Model 4 presents estimates for the historical black and white data, while Model 5 does the same for the modern sample. Black-white and historical-modern regressions are used in the next section's Oaxaca decompositions to account for differences in the source of BMI variation by race and observation period.

Table 4, Nineteenth Century Black and White BMIs by Race, Demographics, Residence, and Socioeconomic Status

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
	Total	Black	White	Historical	Modern
Intercept	32.79***	34.77***	31.60***	32.47***	36.55***
Race					
White	Reference			Reference	Reference
Black	.866***			1.08***	.132***
Height					
Centimeters	-.058***	-.063***	-.053***	-.056***	-.056***
Ages					
18	-1.23***	-1.32***	-1.18***	-1.13***	-2.18***
19	-.834***	-.875***	-.818***	-.740***	-1.73***
20	-.604***	-.607***	-.630***	-.482***	-1.53***
21	-.348***	-.350***	-.381***	-.294***	-.978***
22	-.222***	-.207***	-.265***	-.189***	-.687***
23-29	Reference	Reference	Reference	Reference	Reference
30s	.402***	.327***	.477***	.207***	.988***
40s	.800***	.491***	.956***	.417***	1.38***
50s	.939***	.410***	1.14***	.474***	1.42***
60s	.899***	.366***	1.07***	.276***	1.31***
70s	-.275***	-.678***	-.151***	.144	.030
Residence					
Northeast	-.323***	-.505***	-.162***	-.224***	-.277***
Midwest	-.153***	-.426***	-.080**	-.717***	.069
South	Reference	Reference	Reference	Reference	Reference
West	-.073***	-.211**	-.038	.387***	-.289***
Occupations					
White-Collar	-.173***	-.178***	-.077**	-.248***	.015
Skilled	-.113***	-.189***	.040	-.136***	.153
Farmer	.136***	.149***	.228***	.081***	.172
Unskilled	.006	-.080***	.179***	-.060***	.326***
No Occupation	Reference	Reference	Reference	Reference	Reference
Observation Decade					
1840s	.846***	.352	1.16***		
1850s	-.100	.103	.071		
1860s	.380***	.383***	.419***		
1870s	.158***	.364***	-.021		
1880s	.121***	.105***	.090***		
1890s	.138***	.118***	.125***		
1900s	Reference	Reference	Reference		
1910s	-.232***	-.261***	-.162***		

1920s	-.089	-.130	-.006		
2000s	4.60***	4.22***	4.69***		
N	206,201	73,011	133,190	132,256	74,945
R^2	.3310	.2367	.3589	.1058	.0456

Source: See Table 1.

Notes: *** significant at .01; **Significant at .05; * significant at .10.

Three patterns emerge when comparing 19th and 21st century black and white BMIs. First, during the 19th century, black BMIs were greater than whites; however, the difference has narrowed over the last 200 years (Costa, 2004; Carson, 2009b; Flegal et al., 1998; Flegal et al., 2012), and multiple explanations account for the convergence. BMIs are inversely related with stature, and both historic and modern white statures are taller than blacks (Herbert et al. 1993, p. 1438; Aloia, et al., 1996, pp. 296-298; Komlos and Lauderdale, 2005; Carson, 2009a, p. 155); taller physical statures allow larger dimensions to distribute weight and are associated with lower BMIs (Costa, 2004, p. 4; Henderson, 2005, p. 361). However, because heights have remained constant since the mid-20th century, shorter statures explain only part of why 19th century black BMIs were greater than whites but do not account for the modern convergence. BMIs and obesity are related with physical activity (Lackdawalla and Philipson, 2002, p. 25), and both have increased for less physically active workers in white-collar and skilled occupations. Much of this modern relationship may be related to occupations and how income is earned. Earned labor income in modern sedentary white-collar and skilled occupations is probably positively related with income, while being in low skilled, low income, physically active jobs is inversely related with income and BMIs (Lackdawalla and Philipson, 2002). Whites disproportionately became white collar and skilled occupations, earned more income, became less physically active, and become more obese. Another explanation for increased obesity is the decrease in the relative price of nutrition, and the price of acquiring nutrition has declined considerably since the 19th century (Komlos, 1985; Komlos, 1987; Philipson and Posner, 2003; Lackdawalla, Philipson, and Bhattacharya, 2005). Therefore, black BMIs were initially greater than whites, and while both have increased, the rate of increase for whites is greater than for blacks.

Second, the modern increase in obesity is related with occupations, and US labor markets have transformed from occupations that require more to less physical activity (Rosenbloom, 2000, p. 88; Komlos, 2013, p. 408). For example, there are 276 percent more white-collar workers and 121 percent more skilled workers in the modern sample than among the historical working class. Between 1800 and 2000, there were 89 and 34 percent fewer farmers and unskilled workers in the modern US labor force, and the difference, of course, is a shift from low to high skilled occupations. Nineteenth century US labor markets were predominantly agricultural and required greater physical activity, and higher BMIs are associated with greater physical strength and activity (Must and Evans, 2011, p. 25). This change in the occupational structure is associated with decreased physical activity and increased obesity (Lackdawalla and Philipson 2002, p. 25; Sandy et al. 2011, p. 206; Mortens, et al., 2007; Long et al. 2002). In sum, there was considerable BMI variation by occupation, and modern sedentary white-collar and skilled obesity rates increased as the change in the US labor markets placed previously active farmers and unskilled workers into physically less active white-collar and skilled occupations.

Third, there have been considerable BMI changes by region. During the 19th century, Northeastern BMIs were lower than those in the South and West. Between the 19th and 21st centuries, Northeastern BMIs remained about the same level, Mid-western BMIs increased relative to other regions, while Western BMIs decreased (Carson, 2009b; Carson, 2012; Atlas, 2011, p. 105).[9] Throughout the late 19th and early 20th centuries, the Northeast was the most industrial and urbanized US region, and urban locations require less physical activity than rural locations. On the other hand, between the 19th and 21st centuries, the Mid-west's economy transitioned from a predominantly agricultural to an industrial manufacturing economy, and as physical activity diminished, BMIs increased. Alternatively, the Far West experienced a marked reversal from relatively high 19th to low 21st century BMIs and obesity. Part of the change is due to taller statures in the 21st century western states; however, part of the change is due to increasing obesity rates in other US regions (Must et al., 1999). Moreover, the modern West has become more health conscious, and states like California and cities, such as Denver, have among the lowest contemporary obesity rates in the US (Atlas, 2011, p. 105). The result is that there has been a regional BMI and obesity change between the 19th and 21st centuries, which is associated with changing occupational compositions that required less physical activity and changing health practices that favored Western states.

V. Decomposing the BMIs by Race and Time

To more fully account for the source of the BMI differential, Blinder-Oaxaca decompositions are constructed for the differences between the black-white and historic-modern samples (Oaxaca, 1973).[10] A Blinder-Oaxaca decomposition is a statistical procedure used to detect discrimination but is also used to explain differences between samples that are due to

[9] While there were increasing and decreasing obesity rates by region between 1800 and 1900 (Moddad, Serdula, Dietz, Bownan, Marks, and Koplan, 1999, p. 1522).

[10] The null hypothesis for slope coefficients for male interactive effects in an ancillary regression, not reported here, illustrates that black coefficients are significantly different from mulatto coefficients (F-stat (29, 67,761)=2.46; p-value=.0000).

returns to characteristics and average characteristics. Let BMI_i and BMI_j represent the heaviest and lightest BMI categories, respectively. For example, in a comparison by race, black BMIs, i, are heavier than white BMIs, j. In the historical and modern comparison, historical BMIs are coded as j, and modern BMIs are coded as i. α_i and α_j are the autonomous BMI components that accrue to blacks and whites; β_i and β_j are the black and white BMI returns associated with specific BMI characteristics, such as age and occupation. X_i and X_j are mean black and white characteristic matrices, and the i^{th} group is assumed to be the base structure. Similar decompositions are then constructed for the historical and modern BMI differential. BMI models by race and period are constructed by first regressing black and white BMIs on demographic, residential, socioeconomic status, and observation period.

$$\text{Black BMI function:} \quad BMI_i = \alpha_i + \beta_i X_i$$

$$\text{White BMI function:} \quad BMI_j = \alpha_j + \beta_j X_j$$

The heavy minus light BMI gap is the difference between their characteristics and returns to characteristics.

$$\Delta BMI = BMI_i - BMI_j = \alpha_i + \beta_i X_i - \alpha_j - \beta_j X_j$$

Adding and subtracting $\beta_j X_i$ to the right and side of the equation and collecting like terms leads to

$$\Delta BMI = BMI_i - BMI_j = (\alpha_i - \alpha_j) + (\beta_i - \beta_j)\overline{X}_i + \beta_j(\overline{X}_i - \overline{X}_j)$$

The first right hand side element, $(\alpha_i - \alpha_j)$, is the difference in the BMIs attributable to non-identifiable sources, such as greater bone mineral density and greater present muscle mass that favored darker complexions (Barondess et al., 1997; Wagner and Heyward, 2000). The second right-hand side element, $\left(\beta_i - \beta_j\right)\overline{X}_i$, is the component of the BMI differential associated with differences in characteristic returns. The third right-hand side element, $\beta_j\left(\overline{X}_i - \overline{X}_j\right)$, is the part of the BMI differential due to differences in average characteristics and is undetermined because whites may have had characteristics associated with greater BMI values, but blacks were shorter and had characteristics associated with heavier BMIs.

Table 5, Black versus White BMI Oaxaca Decomposition

	$(\beta_b - \beta_w)\bar{X}_w$	$(\bar{X}_b - \bar{X}_w)\beta_b$	$(\beta_b - \beta_w)\bar{X}_b$	$(\bar{X}_b - \bar{X}_w)\beta_w$
Levels				
Sum	.601	1.13	1.01	-1.54
Total		-.528		-.528
Proportions				
Intercept	3.21		-.601	
Height	-2.05	-.314	3.25	-.264
Ages	-.118	.256	.261	.481
Residence	.320	-.343	.135	-.059
Occupations	.356	.-.091	.345	-.079
Observation Year	.404	.253	1.05	2.83
Total	-1.14	2.14	-1.91	2.91
Sum		1		1

Source: See Tables 1 and 4.

Using coefficients from the black and white regressions (Table 4, Models 2 and 3), the race decomposition indicates the greatest black-white BMI differential is attributable to non-identifiable sources in the intercept (Table 5), such as greater bone mineral density and a greater percent muscle mass that favored blacks. Black BMI returns are greater than whites for residence, occupations, and observation period, and Southern blacks have greater BMI returns compared to blacks who live elsewhere within the US. Historically, Southern diets exceed those from elsewhere, and Southern blacks have been the most physically active (Fogel and Engerman, 1974). The black-white BMI differential is also due to characteristic differences, and both historical and modern whites are taller than blacks and have greater BMI returns associated with height, indicating that whites' net cumulative nutritional advantage is associated with a net current advantage that extends to BMI (Godoy, 2005; Harrison et al., 1977; Carson, 2009b). For both the historic and modern samples, whites are older than blacks, and average BMIs increase with age (Williams and Woods, 2006). However, the greatest share of the BMI gap between blacks and whites is attributable to non-identifiable characteristics in the intercept.

Table 6, Modern versus Historical BMI Oaxaca Decomposition

	$(\beta_m - \beta_h)\bar{X}_h$	$(\bar{X}_m - \bar{X}_h)\beta_m$	$(\beta_m - \beta_h)\bar{X}_m$	$(\bar{X}_m - \bar{X}_h)\beta_h$
Levels				
Sum	3.93	.563	5.03	-.054
Total		4.49		4.49
Proportions				
Intercept	.909		.909	
Black	-.099	-.009	-.032	-.076
Height	0	-.078	0	-.078
Ages	.004	.186	.125	.065
Residence	.001	-.005	.005	-.008
Occupation	.059	.032	.113	-.022
Total	.875	.125	1.11	-.110
Sum		1		1

Source: See Tables 1 and 4.

Modern BMIs are greater than historical values, and the greatest difference between historical and modern BMIs is, again, due to unexplained differences in the intercept (Table 6), such as diets and inexpensive access to calories. There is no difference between the historical and modern BMI returns associated with height; however, modern BMI returns to ages, residence, and occupation are greater than historical values. Modern obesity has increased more among adult populations, and both the South and workers with sedentary occupations have greater BMIs. Nevertheless, historical characteristics that explain the BMI gap are race, height, and residence, and returns to characteristics and average characteristics explains more of the black-white BMI differential than the modern-historic differential. In sum, black-white and modern-historical BMI gaps represent complex economic and social dynamics associated with height, demographics, and socioeconomic status, and BMI differences by race explain more of the difference than by time period.

VI. Conclusion

Modern international BMIs and obesity rates have increased over time and across socioeconomic status, which is associated with increasing health costs. BMI distributions may have increased because the distributions shifted to the right or because the share of individuals in obese categories increased. While the share of black and white males in overweight categories has increased, the share in obese categories has increased by more than the rest of the distribution and is associated with an increase in obesity related diseases (Crimmens and Condran, 1983, p. 33; Musts, et al, 1999, pp. 1525-1527). During the 19th century, blacks had greater average BMIs than whites; however, while both black and white BMIs and obesity have increased, the share of whites in obese categories has increased more than blacks, and there is currently little difference between modern black and white obesity. Multiple explanations account for the increase and convergence, but much is due to shifts in the labor market. During the 19th century, blacks and whites were in physically active occupations; however, modern labor markets have become increasingly skilled. Modern white-collar and skilled workers engaged in less physical activity require fewer calories than their historical counterparts, and modern whites are more likely to be in white-collar and skilled occupations, have higher BMIs, and are more likely to be obese. BMIs and obesity have varied regionally, and black and white males from and Midwest and South have become more obese, while individuals in the West have become less obese. Therefore, there are dynamic relationships between BMIs, observation period, socioeconomic status, and residence, variation overtime, across socioeconomic status, and residence indicates labor market opportunities and physical activity are related with the increase in modern BMIs and obesity between 1800 and the present.

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