CESifo Working Papers
www.cesifo.org/wp

Nineteenth Century US BMIs by Race: Socioeconomics and Biology

Scott Alan Carson

CESIFO WORKING PAPER NO. 3971
CATEGORY 4: LABOUR MARKETS
OCTOBER 2012

CESifo *Working Paper No. 3971*

Nineteenth Century US BMIs by Race: Socioeconomics and Biology

Abstract

Little research exists on late 19th and early 20th century US body mass index value differences by race, and darker complexions were associated with greater BMI values. Mulattos had greater BMI returns associated with socioeconomic characteristics, indicating that while blacks had greater BMIs than fairer complexioned whites and mulattos, part of the difference was offset by socioeconomic characteristics that favored fairer complexions. Black, mulatto, and white BMIs declined between 1860 and 1920, and farmers had greater BMIs than workers in other occupations.

JEL-Code: I100, J110, J710, N310.

Keywords: Nineteenth century US race relations, body mass index, biological inequality.

Scott Alan Carson
University of Texas, Permian Basin
4901 East University
USA – Odessa, TX 79762
carson_s@utpb.edu

I appreciate comments from Tom Maloney, John Komlos, and Paul Hodges.

I. Introduction

Compared to Europeans, 19th century Africans in the US experienced considerable political and economic barriers to economic progress, which were evident in both their material and biological welfare. Black and white material conditions before and after slavery are well documented (Conrad and Meyer, 1964; Fogel and Engerman, 1974; Fogel, 1989; Ransom and Sutch, 1977; Higgs, 1977); however, differences in their biological conditions have received less attention (Steckel, 1986; Bodenhorn, 1999; Rees et al. 2003; Carson, 2008; Carson, 2009). Two common measurements that account for biological living conditions are stature and the body mass index (BMI).[1] Stature measures the net cumulative difference between nutrition, disease exposure, work, and the physical environment, while BMI measures the net current difference between the same variables (Fogel, 1994). Statures and BMIs increase when surrounding material and biological conditions and decrease when they deteriorate. Therefore, while not minimizing the difference between black and white material conditions, this study contrasts 19th century black, mulatto, and white BMIs and demonstrates that a large share of the differences were due to biological rather than socioeconomic characteristics.

Mulattoes were consistently taller than darker complexioned blacks, and Steckel (1979) and Bodenhorn (1999) attribute this to racial preferences that disproportionately favored fairer complexions. However, this explanation is inconsistent with the modern black and white stature

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

differential, where modern whites continue to be taller than mulattos, who are—in turn—taller than darker complexioned blacks (Komlos and Lauderdale, 2005), indicating that 19th century social preferences that favored fairer complexions are not the principal explanation for the modern white-black stature differential. If 19th century social preferences were the primary factors explaining the black-white BMI differential, white values would be greater than mulattos, which would be greater than darker complexioned blacks. In fact, the opposite is true. Darker complexioned black BMIs were consistently greater than mulattos, which were greater than white BMIs, indicating there is more to explaining the 19th century black-white BMI differential than only social preferences (Carson, 2009; Carson, 2012b, pp. 200-203).

It is against this backdrop that this study considers three paths of inquiry into 19th century BMI variation. First, how were black, mulatto, and white BMIs distributed, and did individuals with fairer complexions have greater BMI values than darker complexions? Darker complexioned black BMI values were ironically greater than mulattos and whites, indicating that an aggregate 19th century mulatto advantage did not extend to BMIs. Second, how did black, mulatto, and white BMIs vary overtime? Throughout the 19th century, blacks had greater BMIs than whites, and between 1860 and 1920, adult black, mulatto, and white BMIs decreased by about three, six, and four percent, respectively. Third, how did black, mulatto, and white BMIs compare by socioeconomic status? Farmer BMIs were greater than black, mulatto, and white workers in other occupations by .1, 1.4, and 1.2 percent, respectively, and the majority of the black-white BMI differential was due to biological and ethnic rather than socioeconomic characteristics.

II. Nineteenth Century BMI Variation by Race and Socioeconomic Status

Historical BMI studies provide important insight into the evolution of health during economic development, and for BMIs less than 20, Waaler (1984) and Koch (2011) find inverse relationships between BMIs and mortality risk. Costa (1993) applies Waaler's results to a historical population and finds the modern height and weight relationship with mortality applies to historical populations, and Jee et al. (2006) find the relationship is similar across racial groups. Costa (2004) and Carson (2009) demonstrate there were considerable differences between 19th century black and white BMIs, and blacks had greater BMI values than whites. Costa (2004) finds that BMI values increased between 1860 and 1950, and Cutler, Glaezer, and Shapiro (2003) find that US BMIs increased since the beginning of the 20th century, not because people are physically inactive but because they consume more calories. However, Lakdawalla and Phillipson (2002, p. 25) demonstrate the increase in the late 20th century obesity rates were about 60 percent explained by technology change and decreased physical activity.

Table 1, Comparison of late 19th and 20th Century BMI Studies

Study	Observation Period	Sample	ΔBMI	Mulatto BMI Difference
Cuff, 1993, Whites	1860-1885	West Point Cadets	.77	NA
Komlos and Coclanis, 1995, Whites	1860-1930	The Citadel	1.7	NA
Carson, 2009	1870-1920	Texas Prisoners	Blacks, -.386 Whites, .240	-.334 Compared to Blacks
Carson, 2012	1850-1929	US Prisons	Black Youth -1.06 White Youth -1.05	-.365 Compared to Blacks
Carson, 2012	1840-1929	US Prisons	Black Adults -2.25 Youth Adults -2.00	-.355 Compared to Blacks
Carson and Hodges, 2012	1870-1910	Philadelphia Prison	.185	-.370 Compared to Blacks
Bodenhorn, 2010	1795-1844	New York Legislators	-1.7	NA

Source: Cuff (1993); Coclanis and Komlos (1995); Carson, (2009); Carson (1912); Carson and Hodges (2012); Bodenhorn, 2010.

Several studies consider 19th century US black and white BMI variation, and a few patterns have come into view (Table 1). Among the first and most surprising is that 19th century black and white BMIs were distributed symmetrically and neither high nor low BMIs were common (Carson, 2009, p. 124; Carson, 2012, p. 380). Nineteenth century black and white BMIs decreased throughout the 19th century. Between the 1840s and 1920s, black youth and adult BMIs decreased by 1.60 and 3.79 percent, respectively. White youth and adult BMIs decreased by .956 and 5.40 percent, respectively, indicating that adult white BMIs were influenced more than blacks by the transition from bound to free labor. Across different

samples, darker complexioned blacks had greater BMI values than whites. BMIs were also associated with socioeconomic status, and both black and white adult farmer BMIs were about .59 and .84 percent greater than workers with no occupation. Unskilled workers also worked in agriculture, and black and white adult unskilled workers were about .51 and .72 percent greater than workers with no occupations (Carson, 2012, pp. 383-384). Black and white BMIs varied by residence, and individuals from the rural South consistently had greater BMIs, while BMIs in the urban Northeast were lower than elsewhere within the US (Carson, 2009). Nevertheless, it is unclear by how much darker complexioned black BMIs were greater than mulattos and whites and whether these differences were due to socioeconomic or biological characteristics.

III. Nineteenth Century Black, Mulatto, and White US BMI Data

The two most common sources of historical BMI measurements are military and prison records. Nineteenth century military records provide little height and weight information for African-Americans; therefore, among surviving height and weight data, prison records represent a more inclusive cross-section for 19th century African-Americans. Moreover, prison records may have been drawn from lower socioeconomic groups, that segment of society most vulnerable to economic change (Nicholas and Steckel, 1991; Bogin, 1991, p. 288; Komlos and Baten, 2004, p. 199). Understanding BMI variation is also more problematic than interpreting other biological markers because BMI variation reflects early life conditions (Costa, 2004, p. 4; Law et al. 1992). For example, if an individual is poorly nourished as a youth, their statures may be short, their frames possibly smaller, and their basal metabolic needs would be relatively low. Improved nutrition in later life, therefore, results in greater BMI values. Alternatively, a well-nourished youth may have taller, larger frames, their basal metabolic needs higher, resulting in lower BMIs in later life (Costa, 2004, p. 4; Pettit, Baird, et al. 1983; Baum and Ruhm, 2009).

The data used here is part of a large 19th century prison sample,[2] and most blacks in the sample were imprisoned in the Deep South or Border States—Kentucky, Missouri, and Texas. Most whites in the sample were imprisoned in Missouri and Texas, but Northern whites were also from Pennsylvania and the Far West (Table 2). Physical descriptions were recorded by prison enumerators at the time of incarceration as a means of identification, therefore, reflect pre-incarceration conditions.

Table 2, Nineteenth Century US Black, Mulatto, and White Prison Populations

	Black		*Mulatto*		*White*	
	N	Percent	N	Percent	N	Percent
Arizona	158	.29	36	.27	2,156	2.93
Colorado	408	.75	75	.56	3,502	4.76
Idaho	31	.06	5	.04	575	.78
Kentucky	5,084	9.33	1,083	8.12	6,602	8.97
Missouri	2,530	4.64	1,762	13.21	7,984	10.85
New Mexico	344	.63			1,993	2.71
Oregon	41	.08	4	.03	1,683	2.29
Pennsylvania	2,002	3.67	683	5.12	11,214	15.24
Philadelphia	4,495	8.25	986	7.39	11,410	15.51
Tennessee	17,759	32.60	3,182	23.85	10,384	14.11
Texas	21,631	39.70	5,523	41.40	16,083	21.86
Total	21,631	100.00	13,339	100.00	73,586	100.00

Sources: See Carson, 2012.

Between 1840 and 1920, prison officials routinely recorded the dates inmates were received, age, complexion, nativity, height, pre-incarceration occupation, and crime, and all records with complete age, height, weight, occupations, and nativity are used in this study. There was also care recording inmate height and weight because accurate recordings had legal implications for identification in the event that inmates escaped and were later recaptured.

[2] 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).

Arrests and prosecutions across states may have resulted in various selection biases that may affect the results of this analysis. However, black and white stature variations across US prisons are consistent with other historical health studies (Costa, 2004; Cuff, 1993; Komlos and Coclanis, 1997). Because the purpose of this study is 19th century black and white male BMIs by race, females, immigrants, and ethnicities other than white and black are excluded from the analysis.

Inmate enumerators were quite thorough when recording complexions and pre-incarceration occupations. 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 fair, light, medium, and dark. The white inmate complexion classification is supported further by European immigrant complexions, which had fair complexions and were also recorded as light, medium, and dark.[3] While mulatto inmates possessed genetic traits from both European and African ancestry, they were treated as blacks in the 19th century US.

Enumerators recorded a broad range of occupations and defined them narrowly, recording over 200 different occupations, which are classified here into four categories: merchants and high skilled workers are classified as white-collar workers; light manufacturing, craft workers, and carpenters are classified as skilled workers; workers in the agricultural sector are classified as farmers; laborers and miners are classified as unskilled workers (Tanner, 1977, p. 346; Ladurie, 1979; Margo and Steckel, 1992; p. 520). Unfortunately, inmate enumerators did

[3] I am currently collecting 19th century Irish prison records. Irish prison enumerators also used light, medium, dark, fresh and sallow to describe white prisoners in prisons from a traditionally white population. To date, no inmate in an Irish prison has been recorded with a complexion consistent with African heritage.

not distinguish between farm and common laborers. Since common laborers probably encountered less favorable biological 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.

Table 3, Nineteenth Century Blacks, Mulattos, and Whites by Age, Residence, Observation Period, and Occupations

	Black		*Mulatto*		*White*	
Age	N	Percent	N	Percent	N	Percent
Teens	11,459	21.03	2,585	19.38	10,035	13.64
20s	28,852	52.96	7,277	54.55	36,607	49.75
30s	8,757	16.07	2,317	17.37	16,191	22.00
40s	3,444	6.32	772	5.76	6,841	9.30
50s	1,400	2.57	278	2.08	2,841	3.86
60s	457	.84	100	.75	896	1.22
70s	114	.21	10	.07	175	.24
Residence						
Arizona	158	.29	36	.27	2,156	2.93
Colorado	408	.75	75	.56	3,502	4.76
Idaho	31	.06	5	.04	575	.78
Kentucky	5,084	9.33	1,083	8.12	6,602	8.97
Missouri	2,530	4.64	1,762	13.21	7,984	10.85
New Mexico	344	.63	0	0	1,993	2.71
Oregon	41	.08	4	.03	1,683	2.29
Pennsylvania	2,002	3.67	683	5.12	11,214	15.24
Philadelphia	4,495	8.25	9.86	7.39	11,410	15.51
Tennessee	17,759	32.60	3,182	23.85	10,384	14.11
Texas	21,631	39.70	5,523	41.40	16,083	21.86
Decade Received						
1840s	17	.03	3	.02	165	.22
1850s	36	.07	19	.14	839	1.14
1860s	952	1.75	28	.21	1,307	1.78
1870s	6,777	12.44	838	6.28	3,748	11.89
1880s	10,373	19.04	2,136	16.01	10,888	14.80
1890s	11,843	21.74	2,442	18.31	14,114	19.18
1900s	12,534	23.01	3,785	28.38	17,782	24.16
1910s	11,205	20.57	3,885	29.13	18,533	25.19
1920s	746	1.37	203	1.52	1,210	1.64
Occupations						

White-Collar	1,141	2.09	606	4.54	7,024	9.55
Skilled	3,736	6.86	1,411	10.58	16,395	22.28
Farmers	5,207	9.56	1,204	9.03	7,307	9.93
Unskilled	30,700	56.35	7,851	58.86	32,289	43.88
No Occupation	13,699	25.14	2,267	17.00	10,571	14.37
Total						

Sources: See Table 2.

Table 3 presents black, mulatto, and white BMIs by age, birth decade, occupations, and nativity. Although average BMIs are included, they are not reliable because of possible compositional effects, which are accounted for in the regression models that follow. Whites were a larger portion of the prison population than blacks; 52 percent of the US prison population was white; nine percent was mulatto; 39 percent was black. Age percentages demonstrate that black inmates were incarcerated at younger ages, and whites were incarcerated at older ages. Nineteenth century blacks and mulattos were more likely to be from the South, while whites were more likely to be from the Middle-Atlantic (Steckel, 1983). During the early 19th century, blacks and mulattos were less likely to be incarcerated for crimes committed while they were slaves; 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.[4] Nineteenth century whites were more likely than blacks to be white-collar, skilled workers, and farmers. Blacks were more likely to be unskilled.

The shape of the BMI distribution demonstrates important insight on the net nutritional environment facing a population, and there are differing views on how 19th century BMIs were

[4] 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).

distributed. Given similar means, a positively skewed BMI distribution indicates a disproportionate number of underweight individuals, while a negatively skewed distribution indicates obesity is more prevalent. Using the World Health Organization's BMI classification scheme for modern standards, 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.[5] Because BMIs are sensitive to age, individuals younger than 22 are classified as youth, while individuals 22 and older are classified as adults.

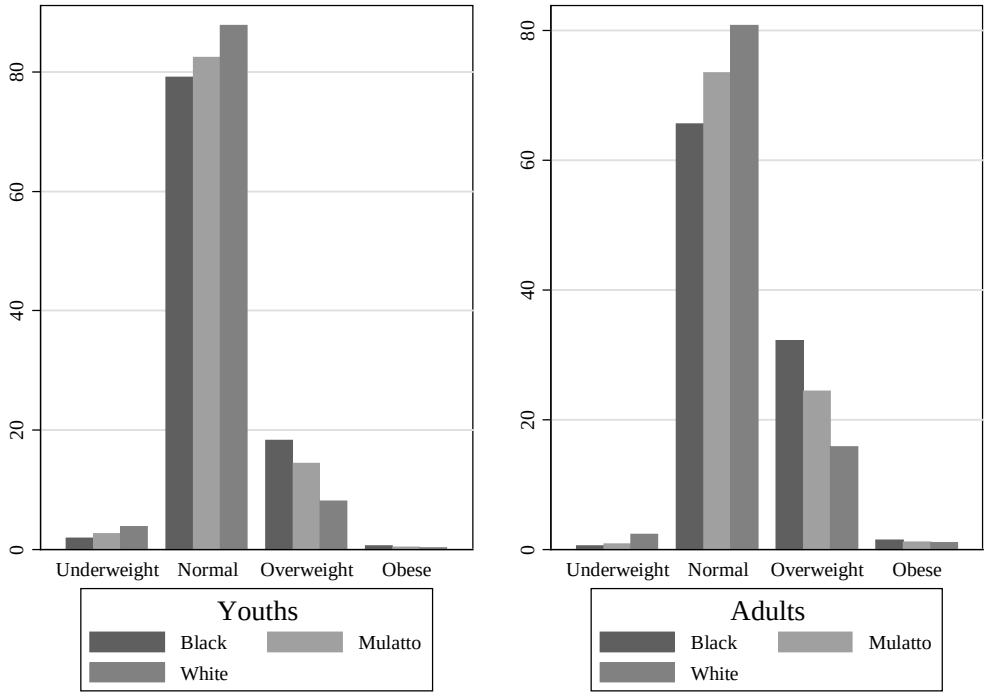

Figure 1, Nineteenth Century Underweight, Normal, Overweight, and Obese BMIs by Race and Age

[5] WHO (1997) and National Heart, Lung, and Blood Institute (1998, pp. 14-16) indicate an optimal BMI is between 20 and 22.

Sources: See Table 1.

Notes: Individuals younger than 22 are classified as youth; individuals 22 and older are classified as adults.

Contrary to modern standards, the majority of 19th century blacks, mulattos, and whites were in normal weight ranges, and youths were more likely than adults to be in the normal weight category (Figure 1; Flegal et al. 2012; Flegal et al. 2010; Must and Evans, 2011, pp. 11-12). Individuals with darker complexions were also more likely to be in overweight and obese categories, and individuals with fairer complexions were more likely to be in the underweight category (Costa, 2004; Carson, 2009). Twenty three percent of 19th century adult males were overweight, and only 1.5 percent were obese. These values are in marked contrast with contemporary US BMI classifications, where approximately 63.5 percent of modern adult males between ages 20 and 39 are overweight, and 27.5 percent are obese (Flegal, et al. 2012; Flegal et al. 2010, p. 236; Sturm and Wells, 2001, p. 231; Calle et al. 1999, p. 1103).

Average BMIs also varied by age and race, and average 19th century black, mulatto, and white youth BMIs were 23.03, 22.63, and 21.96, respectively. Average black, mulatto, and white adult BMIs were 24.07, 23.53, and 22.78, respectively. However, heavier black BMIs are not necessarily a sign of superior darker complexioned biological conditions, because 19th century BMIs were inversely related with height, and blacks were shorter than whites (Herbert et al. 1993, p. 1438; Carson, 2009, pp. 125-126; Carson, 2012, pp. 382-387). Fairer complexioned individuals were consistently taller than blacks and had larger physical dimensions with which to distribute weight. Therefore, the majority of 19th century black, mulatto, and white BMIs were

in normal weight ranges, and darker complexioned BMIs were greater than fairer complexioned individuals.

IV. The Comparative Effects by Race for Demographics, Occupations, and Residence with BMI

We test which of these variables were associated with 19th century black, mulatto, and white BMIs. To start, BMIs are partitioned into black, mulatto, and white cohorts, and the ith individual's is assumed to be related with height, age, decade received, occupations, and residence.

$$BMI_i = \alpha + \beta_c Centimeters_i \sum_{a=14}^{70} \beta_a Age_i + \sum_{t=1840}^{1920} \beta_t Decade\ Received_t + \sum_{l=1}^{4} \beta_l Occupation_i$$

$$+ \sum_{r=1}^{6} \beta_r Residence_{i,t} + \varepsilon_{i,t}$$

Centimeters are added to account for the inverse relationship between BMI and height. Youth age dummy variables are included for ages 14 through 22; adult age decade dummy variables are included from the 30s through the 70s. Observation decade dummy variables are included for the 1840s through 1920s. Occupation dummy variables are included for white-collar, skilled, agricultural, and unskilled occupations. Residence dummy variables are included for residence in Kentucky, Missouri, Pennsylvania, Philadelphia, Tennessee, Texas, and Western states.

Table 4, Nineteenth Century Black, Mulatto, and White BMI Models by Age, Residence, Observation Period, and Occupations

	White		*Mulatto*		*Black*	
Intercept	31.65***	.304	35.84***	.764	36.29***	.410
Height						
Centimeters	-.051***	.002	-.066***	.004	-.070**	.002
Ages						
14	-2.50***	.261	-3.53***	.283	-3.78***	.134
15	-2.17***	.189	-3.00***	.199	-3.22***	.089
16	-1.77***	.077	-2.20***	.138	-2.45***	.060
17	-1.33***	.052	-1.58***	.107	-1.77***	.049
18	-.947***	.039	-1.20***	.081	-1.36***	.040
19	-.597***	.036	-.707***	.078	-.921***	.041
20	-.389***	.036	-.460***	.078	-.625***	.040
21	-.263***	.034	-.471***	.081	-.317***	.039
22	-.174***	.033	-.237***	.072	-.200***	.038
23-29	Reference		Reference		Reference	
30s	.225***	.024	.249***	.059	.203***	.031
40s	.488***	.036	.522***	.102	.273***	.047
50s	.567***	.056	.419***	.158	.264***	.071
60s	.330***	.107	-.057	.244	.109	.118
70s	.605**	.268	1.19	1.12	-.769***	.224
Received						
1840s	1.09***	.210	1.15	1.12	.404	.493
1850s	-.079	.099	.257	1.07	.046	.417
1860s	Reference		Reference		Reference	
1870s	-.633***	.073	-.984**	.443	-.114	.089
1880s	-.710***	.074	-1.13***	.439	-.533***	.089
1890s	-.603***	.072	-1.06**	.437	-.446***	.088
1900s	-.655***	.073	-1.25***	.438	-.509***	.089
1910s	-.701***	.074	-1.46***	.437	-.599***	.089
1920s	-.897***	.107	-1.52***	.467	-.810***	.126
Occupations						
White-Collar	.165***	.043	-.151	.112	-.107	.078
Skilled	.258***	.033	.079	.089	.054	.050
Farmers	.391***	.040	.505***	.091	.308***	.043
Unskilled	.366***	.031	.271***	.071	.203***	.035
No Occupations	Reference		Reference		Reference	
Residence						
West	.496***	.032	.449**	.224	-.013	.080
Kentucky	-.380***	.039	-.793***	.083	-.494***	.039
Missouri	-.570***	.036	-.711***	.068	-.751***	.053

Pennsylvania	.199***	.031	-.312***	.093	-.461***	.056
Philadelphia	-.245***	.031	-.492***	.080	-.596***	.038
Tennessee	.477***	.035	.373***	.066	.252***	.033
Texas	Reference		Reference		Reference	
N	73,586		13,339		54,483	
R^2	.0737		.1153		.1211	

Sources: See Table 2.

Three paths of inquiry are considered when examining 19th century BMI variation by race and complexion. First, Steckel (1979) and Bodenhorn (1999) demonstrate there was a 19th century mulatto stature advantage and attribute it to social preferences that favored fairer compared to darker complexions. If these social preferences extended to BMIs, whites should have had greater BMI values than mulattos, who should have had greater BMIs than darker complexioned blacks. After controlling for compositional effects, black BMIs were greater than mulattos, which were greater than for whites (Flegal et al. 2010); mulattos had about 13.2 percent greater BMIs than whites, while darker complexioned blacks had about 14.7 percent greater BMIs than whites (Table 4). Multiple explanations account for darker complexioned black BMIs. Blacks have greater bone mineral density and greater percent muscle mass than whites, and muscle is heavier than fat (Wagner and Heyward, 2000; Flegal et al. 2010, p. 240). Moreover, after slavery, blacks devoted a greater share of their incomes than whites to food acquisition (Higgs, 1977, p. 105). Therefore, blacks had greater BMI values than mulattoes, who had greater BMIs than whites, and the difference persists after controlling for socioeconomic characteristics.

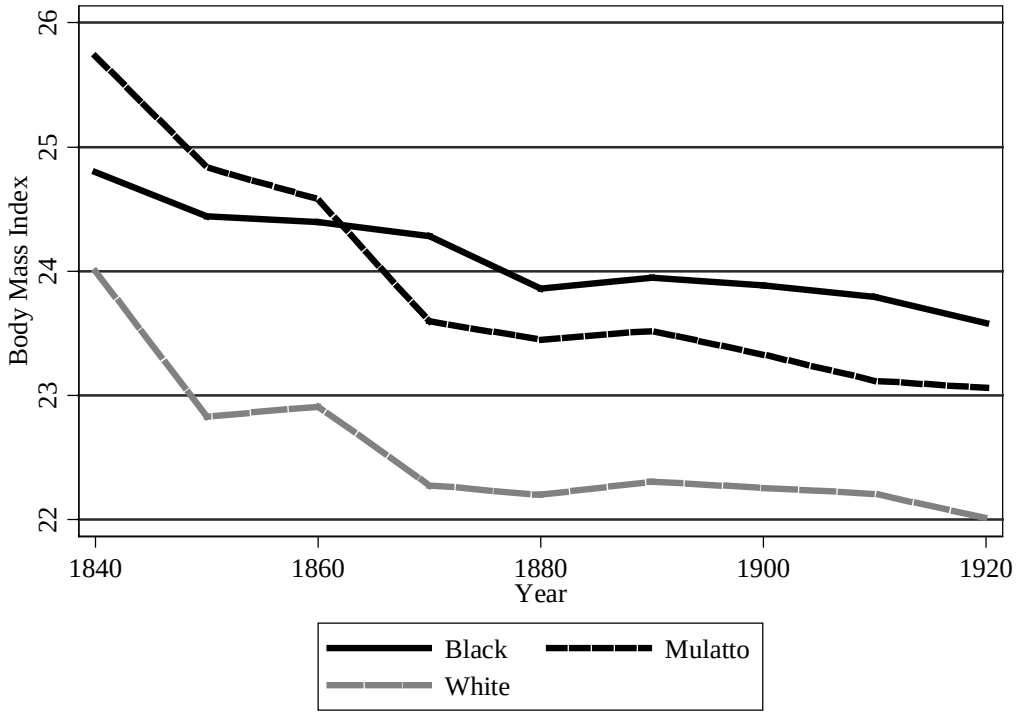

Figure 2, Nineteenth Century Black, Mulatto, and White BMIs over Time

Sources: See Table 4.

Second, it is unclear how black and white BMIs varied overtime because before emancipation, blacks were in a paternalistic system that provided nutrition relative to their labor productivity. After emancipation, the plantation system's efficiency was uprooted, and blacks were left to fend for themselves. Working class black, mulatto, and white BMIs decreased throughout the late 19th and early 20th centuries (Figure 2). Between 1840 and 1860, black BMIs decreased by 1.6 percent; mulattos and whites by 4.5 percent. Between 1860 and 1920, black BMIs decreased by 4.9 percent; mulatto BMIs decreased by 10.4 percent; white BMIs declined by 8.3 percent, indicating that working class white net nutritional conditions were influenced

more than blacks with the transition to free labor. Consequently, 19th century US labor market disruptions were not only related to black health but also extended to the white working class, and for the first time, free working class white labor had to compete with black labor class occupations. Therefore, 19th century BMIs varied by race, and black BMI variation with socioeconomic status was less than for mulattos and whites.

Third, 19th century farmers had greater BMI values than workers in other occupations, and part of agricultural workers' heavier BMIs were related with close proximity to rural diets and mild disease environments. However, parts of agricultural workers' heavier BMIs were related to greater physical activity (Strauss and Thomas, 1998, p. 774). BMIs represent an individual's composition between muscle and fat, which are related to workers' physical activity, therefore, occupations. Occupations that require greater physical activity increase muscle and decrease fat, and for the same tissue mass, muscle is heavier than fat. Agricultural workers use between 1.75 and 1.90 multiples of basal metabolic rates (Mifflin et al. 1990; McArdle et al 1996), while skilled and white collar workers only use between 1.2 and 1.375 multiples of basal metabolic rate. Because of their physical inactivity relative to calories, skilled and white collar workers were less physically active and had lower BMIs than workers in other occupations.

Table 5, Nineteenth Century BMI Variation by Race, Observation Period, Occupation, and Residence

	Total	Height Omitted	Race Omitted	Age Omitted	Observation Period Omitted	Occupation Omitted	Residence Omitted
Intercept	32.60***	22.72***	34.92***	29.61***	32.63***	33.01***	32.91***
Height							
Centimeters	-.059***		-.068***	-.042***	-.059***	-.058***	-.057***
Race							
White	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Mulatto	.778***	.853***		.724***	.749***	.788***	.770***
Black	1.15***	1.26***		1.11***	1.13***	1.16***	1.20***
Ages							
14	-3.43***	-2.73***	-3.32***		-3.42***	-3.45***	-3.32***
15	-2.86***	-2.36***	-2.79***		-2.84***	-2.87***	-2.77***
16	-2.16***	-1.83***	-2.12***		-2.15***	-2.16***	-2.12***
17	-1.55***	-1.34***	-1.56***		-1.55***	-1.55***	-1.53***
18	-1.15***	-1.03***	-1.16***		-1.15***	-1.15***	-1.15***
19	-.744***	-.667***	-.767***		-.748***	-.744***	-.746***
20	-.484***	-.453***	-.490***		-.485***	-.485***	-.484***
21	-.301***	-.283***	-.303***		-.298***	-.299***	-.296***
22	-.185***	-.175***	-.182***		-.184***	-.183***	-.183***
23-29	Reference	Reference	Reference	Reference	Reference	Reference	Reference
30s	.211***	.209***	.174***		.203***	.206***	.212***
40s	.418***	.445***	.368***		.409***	.415***	.425***
50s	.462***	.519***	.377***		.452***	.462***	.494***
60s	.237***	.320***	.155**		.221***	.241***	.287***
70s	.108	.243	.054		.090	.101	.131
Observation Period							
1840s	.887***	.707***	.567***	1.19***		.670***	.552***
1850s	-.155*	-.208***	-.519***	.049		-.256***	-.341***
1860s	Reference	Reference	Reference	Reference	Reference	Reference	Reference
1870s	-.196***	-.250***	-.037	-.139***		-.206***	-.339***
1880s	-.350***	-.430***	-.108**	-.317***		-.314***	-.348***
1890s	-.293***	-.342***	-.081	-.221***		-.264***	-.288***
1900s	-.352***	-.382***	-.111**	-.262***		-.313***	-.429***
1910s	-.441***	-.467***	-.218***	-.291***		-.405***	-.582***
1920s	-.647***	-.681***	-.540***	-.517***		-.508***	-.458***
Occupation							

White-Collar	.053	.064*	-.202***	.359***	-.029		-.196***
Skilled	.160***	.174***	-.062**	.442***	.088***		-.097***
Farmer	.369***	.297***	.266***	.535***	.266***		.205***
Unskilled	.261***	.254***	.296***	.386***	.196***		-.045***
No Occupation	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Residence							
West	.471***	.565***	-.026	.611***	.401***	.433***	
Missouri	-.563***	-.464***	-.849***	-.482***	-.670***	-.592***	
Pennsylvania	.075***	.304***	-.358***	.290***	.069***	.029	
Philadelphia	-.335***	-.113***	-.644***	-.171***	-.349***	-.415***	
Tennessee	.449***	.549***	.516***	.479***	.388***	.292***	
Texas	Reference	Reference	Reference	Reference	Reference	Reference	Reference
N	141,408	141,408	141,408	141,408	141,408	141,408	141,408
R^2	.1329	.1086	.0948	.0758	.1315	.1314	.1198

Sources: See Table 2.

After controlling for socioeconomic status, blacks consistently had greater BMI values than whites (Costa, 2004); however, the source of the difference is less clear. One explanation is that fairer complexioned blacks had greater biological advantages, such as in utero conditions, greater percent muscle mass, and bone mineral density. An alternative explanation is that heavier 19th century black BMIs was due—at least in part—to socio-economic characteristics that favored fairer complexions. Measuring how much of the BMI difference was due to socioeconomic characteristics and how much was due to biological conditions is measured by assuming the source of BMI variation is due to either socioeconomic or biological characteristics.

$$\beta_t = \beta_{SE} + \beta_{Bio}$$

where $ß_t$ is total variation associated with socioeconomic status and biological characteristics; $ß_{SE}$ is the variation associated with only socioeconomic status, and $ß_{Bio}$ is the BMI variation by race associated with biological factors. Measuring the difference between the total and socioeconomic effects provides a magnitude of how BMIs varied by biological factors, and if omitting occupations and socioeconomic characteristics from the unrestricted model do not change race coefficients in the unrestricted model, occupations and socioeconomic status had little explanatory power in BMI variation by race. If, on the other hand, if there is a large difference between the unrestricted race coefficients when socioeconomic status is omitted, occupations and socioeconomic status had large and significant relationships between BMI and race. For example, the dark black coefficient for the unrestricted model (Model 1) is 1.17, and there is almost no change in the total BMI effects associated with race when socioeconomic characteristics are omitted. Comparing the unrestricted and restricted model specifications with other omitted variables are repeated for remaining socioeconomic characteristics—such as nativity, time, and residence with the same results than the race affect is unchanged. On the other hand, when race is omitted, there are considerable differences for occupation variables, especially white-collar and skilled occupations, and 19th century BMI variation by race persisted after socioeconomic characteristics are omitted. Therefore, BMI variation with socioeconomic characteristics are greater when race is omitted, indicating the majority of net cumulative biological variation was due to biological differences between blacks and whites.

V. Explaining the Complexion BMI Differential

To more fully account for the US black, white, and mulatto BMI differentials and to assign relative magnitudes to characteristic effects, a series of Blinder-Oaxaca decompositions are constructed between darker complexioned blacks, mulattos, and whites (Oaxaca, 1973).

BMIs are first classified into categories based on average BMIs. BMI_h and BMI_l represent the body mass of the complexion group with the higher and lower values. α_h and α_l are the autonomous BMI components that accrue to the high and low group, respectively. β_h and β_l are the higher and lower returns associated with specific BMI enhancing characteristics, such as age and occupation. X_h and X_l are the characteristic matrices for the heavier and lower group, and the heaviest BMI group is assumed to be the base structure.

$$\Delta BMI = BMI_h - BMI_l = (\alpha_h - \alpha_l) + (\beta_h - \beta_l)\overline{X}_h + \beta_l(\overline{X}_h - \overline{X}_l)$$

The second right hand-side element is the component of the BMI differential due to characteristic returns. The third right-hand side element is the part of the BMI differential due to differences in average characteristics. Using coefficients from the BMI regressions (Tables 4), the BMI Oaxaca decompositions by complexion (Table 6) indicates the majority of heavier BMIs were due to unobservable characteristics, such as greater bone mineral density and a higher percent muscle mass that favored darker complexions (Barondess et al. 1997; Flegal et al. 2010, p. 240; Wagner and Heyward, 2000).

Table 6, Nineteenth Century Black, Mulatto, and White BMI Decompositions

Blacks to Whites	$(\beta_h - \beta_l)\bar{X}_h$	$(\bar{X}_h - \bar{X}_l)\beta_l$	$(\beta_h - \beta_l)\bar{X}_l$	$(\bar{X}_h - \bar{X}_l)\beta_h$
Levels				
Sum	1.170	-.049	1.014	.107
Total		1.121		1.121
Proportions				
Intercept	4.141		4.141	
Centimeters	-2.881	.065	-2.906	.089
Ages	-.138	-.148	-.102	-.185
Received	.168	-.007	.161	-1.0^{-4}
Occupations	-.107	-.007	-.135	.022
Residence	-.138	.053	-.255	.169
Sum	1.044	-.044	.905	.095
Total		1		1
Mulattos to Whites				
Levels				
Sum	.782	-.139	.747	-.105
Total		.642		.642
Proportions				
Intercept	6.525		6.525	
Centimeters	-3.985	.061	-4.003	.079
Ages	-.120	-.220	-.078	-.262
Received	-.891	-.036	-.830	-.097
Occupations	-.123	.020	-.156	.054
Residence	-.190	-.041	-.295	.064
Sum	1.217	-.217	1.163	-.163
Total		1		1
Blacks to Mulattos				
Levels				
Sum	.320	.159	.352	.126
Total		.478		.478
Proportions				
Intercept	.941		.941	
Centimeters	-1.421	.092	-1.427	.097
Ages	-.144	-.070	.129	-.086
Received	1.489	-.132	1.540	.087
Occupations	-.121	-.006	-.122	-.005
Residence	-.075	.185	-.061	.171
Sum	.668	.332	.736	.264
Total		1		1

Sources: See Tables 2 and 4.

Occupations reflect socioeconomic status, and in each case, lighter complexioned individuals had greater BMI returns related to complexions than darker complexioned individuals. Racial prejudice was dominant throughout the 19th century US, and height, occupations, and residence suggests there was a BMI advantage to fairer complexions. However, advantages to fairer complexions were not sufficient to offset darker complexioned bone mineral density and greater percent muscle mass. Therefore, an aggregate 19th century BMI advantage that favored darker complexions did not materialize; nevertheless, BMI returns associated with the socioeconomic factors of occupations and residence favored individuals with fairer complexions.

VI. Discussion

There were complex 19th century biological differences associated with skin pigmentation and health that reflect broader economic and social changes shaping the US economy. Overall, there was no aggregate BMI advantage to fairer complexioned individuals, and fairer complexions were associated with lower BMI values than individuals with darker complexions. Black, mulatto, and white BMIs decreased throughout the 19th century and farmers consistently had greater BMI values than workers in other occupations. However, decomposing black, mulatto, and white BMIs by characteristics demonstrates that the most direct measures for socio-economic status—heights, occupations, and residence—favored individuals with fairer complexions, demonstrating that, although there was no aggregate BMI advantage for fairer complexions, BMI returns favored fairer complexions. Therefore, 19th century BMI variation for darker complexioned blacks, mulattos, and whites were the result of complex biological and socioeconomic characteristics, and biological differences account for the majority

of BMI differences between blacks and whites.

References

Barondess, D. A. Nelson, D A., & Schlaen, S. E., (1997) "Whole Body Bone, Fat and Lean Mass in Black and White Men," *Journal of Bone and Mineral Research,* 12, 967-971.

Baum, C. L. and C. J. Ruhm. 2009. "Age, Socioeconomic Status and Obesity Growth." *Journal of Health Economics* 28: 635-648.

Bodenhorn Howard. (2010). "Height and body mass index values of nineteenth-century New York legislators." *Economics and Human Biology*. 8(1). pp. 121-126.

Bodenhorn, Howard. "A Troublesome Caste: Height and Nutrition of Antebellum Virginia's Rural Free Blacks." *Journal of Economic History* 59, 4 (December 1999): 972-996.

Bogin, Barry, "Measurement of Growth Variability and Environmental Quality in Guatemalan Children," *Annals of Human Biology,* 18(4), 1991, pp. 285-294.

Calle, Eugenia, Michael Thun, Jennifer Petrelli, Carmen Roriguez, and Clark Meath. "Body-Mass Index and Mortality in a Prospective Cohort of U.S. Adults." *New England Journal of Medicine* 341, no. 15 (1999): 1097-1104.

Carson, Scott Alan. (2012a), "Nineteenth Century Race, Body Mass, and Industrialization: Evidence from American Prisons," *Journal of Interdisciplinary History*. pp. 371-391.

Carson, Scott Alan and Paul Hodges. (2012b), "'Black and white body mass index values in 19th century developing Philadelphia County." *Journal of BioSocial Science*. 44(3), pp. 273-288.

Carson, Scott Alan. (2012) "Was the Relationship between Stature and Insolation Similar across Independent Sample: Evidence from Soldier and Prisoner Data." *Journal of Social Economics.* pp. 199-207.

Carson, Scott Alan (2009) "Racial Differences in Body Mass Indices of Men Imprisoned in 19th Century Texas." *Economics and Human Biology* 7(1): pp. 121-129.

Carson, S.A., 2008. Health during industrialization: evidence from the 19th century Pennsylvania state prison system. *Social Science History* 32, 347-372.

Cawley, John and Barrett Kirwan. 2011. "Agricultural Policy and Childhood Obesity." In: Cawley, John (ed.) *The Oxford Handbook of the Social Science of Obesity*. Oxford University Press: Oxford, pp.480-491.

Coclanis, Peter and John Komlos (1995). "Nutrition and Economic Development in Post Reconstruction South Carolina: an Anthropometric." *Social Science History* 19 pp. 91-116.

Conrad, Alfred H. and John R. Meyer. *The Economics of Slavery and other Studies in Econometric History.* Chicago, IL: Aldine Publishing Company, 1964.

Costa D., 2004. The measure of man and older age mortality: evidence from the Gould sample. *The Journal of Economic History* 64, 1-23.

Costa, D. (1993) 'Height, wealth, and disease among Native-born in the rural, antebellum north', *Social Science History*, 17: 355-83.

Cuff, T. (1993) "The body mass index values of nineteenth century West Point cadets: A theoretical application of Waaler's curves to a historical population,' *Historical Methods*, 26: 171-83.

Cutler, D.M., Glaeser, E.L., Shapiro. J., 2003. Why have Americans become more obese? *Journal of Economic Perspectives* 17, 93-118.

Flegal, Katherine, Margeret Carroll, Brian Kit, and Cynthia Ogden, (2012). "Prevalence of Obesity and Trends in the Distribution of Body Mass Index Among US Adults, 1999-2010." *Journal of the American Medical Association.* 307 pp. 491-497.

Flegal, K., Carroll, M., and Ogden, C., 2010. Prevalence and trends in obesity among US adults, 1999-2008. *Journal of the American Medical Society* 303, 235-241.

Fogel, Robert W. "Economic Growth, Population Theory and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy." *American Economic Review* 84, 3 (June 1994): 369-395.

Fogel, Robert W. *Without Consent or Contract: The Rise and Fall of American Slavery.* New York: W. W. Norton. 1989.

Fogel Robert W. and Stanley L Engerman. 1974. *Time on the Cross: The Economics of American Negro Slavery.* New York: W. W. Norton.

Friedman, Lawrence M. *Crime and Punishment in American History.* New York: Basic Books , 1993.

Herbert,P., Richards-Edwards, J., Manson, J.A., Ridker, P., Cook, N., O'Conner, G., Buring, J., Hennekens, C., 1993. Height and incidence of cardiovascular disease in male physicians. *Circulation* 88, 1437-1443.

Higgs, Robert. *Competition and Coercion.* Chicago: University of Chicago Press. 1977.

Himes, Christopher. 2011. "The Demography of Obesity." In: Cawley, John (ed.) *The Oxford Handbook of The Social Science of Obesity.* Oxford: Oxford University Press: 35-47.

Jee, Ha Jee, Jae Woong Sull, Jengyoung Park, Sang-Yi Lee, Heechoul Ohrr, Eliseo Guallar and Jonathan Samet. "Body-Mass Index and Mortality in Korean Men and Women," *New England Journal of Medicine*, 355(8), August, 2006. pp. 779-787.

Koch, D., 2011. Waaler revisited: the anthropometrics of mortality. *Economics and Human Biology* 9, 106-117.

Komlos, J. & Lauderdale, B. E. (2005) Underperformance in affluence: the remarkable relative decline in the U.S. heights in the second half of the 20th Century. *Social Science Quarterly* 2, 283-305.

Komlos, John and Jörg Baten (2004) "Anthropometric Research and the Development of Social Science History. *Social Science History*. 28: 191-210.

Komlos, J., Coclanis, P., 1997, On the Puzzling Cycle in the Biological Standard of Living: The Case of Antebellum Georgia." *Explorations in Economic History* 34, 433-59.

Lakdawalla, D. and T. Philipson. 2002. "The Growth of Obesity and Technological Change: a Theoretical and Empirical Examination." NBER Working Paper 8946.

Ladurie, E. Le Roy, 1979, The Conscripts of 1968: A Study of the Correlation between Geographical Mobility, Delinquency and Physical Stature and Other Aspects of the Situation of the Young Frenchman Called to Do Military Service that Year. In: Reynolds B, Reynolds S, editors. *The Territory of the Historian*, (Chicago: University of Chicago Press). 33-60.

Law C. M., Barker D.J.P., Osmond C., Fall C.H.D., Simmonds S. J.*(1992)* "Early growth and abdominal fatness in adult life." *Journal of Epidemiol. Community Health 46:184–186.*

Margo, Robert and Richard Steckel. 1992, "The Nutrition and Health of Slaves and

antebellum Southern whites." in *Without Consent or Contract: Conditions of Slave Life and the Transition to Freedom,* edited by R. W. Fogel and S. L. Engerman, New York: Norton, 508-521.

McArdle,William, Frank Katch, and Victor Katch. 1996. Exercise Physiology 4th edition Baltimore:Williams and Watkins

Mifflin, M.D., St Jeor, ST, Hill, LA, Scott, BJ, Daugherty, SA and YO Koh (1990) "A new predictive equation for resting energy expenditure in healthy individuals." *American Journal of Clinical Nutrition*, Vol 51, pp. 241-247.

Must, Aviva and Whitney Evans. 2011. "The Epidemiology of Obesity" In: Cawley, John (ed.) *The Oxford Handbook of the Social Science of Obesity.* 9-34.

National Heart, Lung and Blood Institute, National Institute of Health. 1998. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults—The Evidence Report. *Obesity Research 6* (Suppliment 2): 51S-215S.

Nicholas, S., Steckel, R. (1991) 'Heights and living standards of English workers during the early years of industrialization', *Journal of Economic History*, 51: 937-57.

Pettit, D.J., H.R. Baird et al. 1983. "Excessive Obesity in Off-Spring of Pima Women with Diabetes during Pregnancy." *New England Journal of Medicine* 308: 242-245.

Popkin Barry. M. "Nutritional patterns and transitions." *Population Development Review* 19(1993): 138-157.

Ransom Roger and Richard Sutch. *One Kind of Freedom: the Economic Consequences of Emancipation*. Cambridge: Cambridge University Press, 1977.

Rees, R, John Komlos, Ng Long, and Ulrik Woitek. "Optimal Food Allocation in a Slave Economy." *Journal of Population Economics* 16 (February 2003): 21-36.

Richard H. Steckel, ”The Economic Foundations of East-West Migration during the Nineteenth Century," *Explorations in Economic History* 20 (January 1983): 14-36.

Steckel, R.H. (1979) ‘Slave height profiles from coastwise manifests.’ *Explorations in Economic History* 16: 363-380.

Steckel, Richard. “A Peculiar Population: The Nutrition, Health, and Mortality of American Slaves from Childhood to Mortality.” *Journal of Economic History* 46, 3 (September 1986): 721-41.

Sturm, R and KB Wells, “Does Obesity Contribute as much to Morbidity as Poverty or Smoking?” *Public Health*, 115, 2001, pp. 229-236.

Tanner, James M, 1977, “Human Growth and Constitution,” in Harrison, GA, Weiner, JS, Tanner, JM, and Barnicot, NA (eds) *Human Biology: an Introduction to Human Evolution, Variation, Growth and Ecology.* pp. 301-384.

Wagner, Dale and Vivian Heyward. 2000, “Measures of Body Composition in Blacks and White: A Comparative Review.” *American Journal of Clinical Nutrition.* 71, pp. 1392-1402.

Wahl, Jenny B. "The Jurisprudence of American Slave Sales." *Journal of Economic History* 56, no. 1 (March, 1996): 143-69.

Wahl, Jenny B. “Legal Constraints on Slave Masters: The Problem of Social Costs,” *The American Journal of Legal History* 41, no. 1 (January, 1997): 1-24.

Waaler, Hans T. “Height, Weight and Mortality: the Norwegian Experience,” *Acta Medica Scandinavia,* suppl. 679, (1984): 1-51.

World Health Organization (WHO). 1997. *Obesity: Preventing and Managing the Global Epidemic.* Geneva: World Health Organization.