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Abstract

When other measures for economic welfare are scarce or unreliable, the use of biological measures are now standard in economics. This study uses late 19th and early 20th century BMI, statures, and weight to assess how net nutrition accumulated to women and men during US economic development. Throughout the late 19th and early 20th centuries, female and male BMIs, statures, and weight remained constant over time. Unskilled laborers' BMIs were higher, their statures were taller, and their weights heavier than workers in other occupations. Women and men from the Northeast and Middle Atlantic had higher BMIs and shorter statures, while their counterparts from the South were taller and had lower BMIs, indicating that it was superior Southern cumulative net nutrition associated with lower BMIs.

JEL-Codes: C100, C400, D100, I100, N300.

Keywords: BMI variation, stature, economic transition, Oaxaca Decompositions.

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I. Introduction

Nineteenth and early 20th century United States resource allocation by gender—both within the household and the economy—is an important area in development studies. In traditional economies during economic development, greater physical strength in required, and men receive allocative priority to women (Burnette, 2013, p. 306; Marques et al, 2019, p. 158; Williams et al 2019, pp. 278-297). However, measuring women and men's material and nutritional differences is difficult because household resources are shared resources, which masks their relationships within the household and makes separating material conditions by gender difficult. Nevertheless, over the last 40 years, alternative measures have been developed that provide insight into economic and household resource allocation related to economic welfare (Floud et al., 2011, p. 35; Osmani and Sen, 2003). Body mass, height, and weight are three measures used to assess women and men's biological conditions before modern economic measures were developed. A population's average body mass index (BMI) reflects the net current difference between calories consumed and calories required for work and to withstand the physical environment (Waaler, 1984; Berrington de Gonzalez, 2010, pp. 2213-2218; Koch, 2011; Roberts and Steckel, 2019, pp. 327-330).[1] A population's average stature reflects the cumulative net difference between the same variables, and a population's average weight, after controlling for height, is a complement to BMI and avoids the mis-matched effect between weight and height inherent with BMI. Each are used here to examine net nutrition and health by gender as the United States developed in the late 19th and early 20th centuries (Carson, 2018b).

Because women did not have incomes and wealth independent from their fathers and husbands, average BMIs, stature, and weight reflect individual net nutrition masked by household income and wealth (Fogel et al. 1978; Fogel, et al. 1979; Fogel, Engermann, and Trussel, 1982). By evaluating average versus individual biological measures, genetic differences are mitigated, leaving only the individual effects of economic and physical environments on net nutrition. As a ratio of weight to height, interpreting BMI variation is difficult because a population's BMI increases when weight in the denominator increases or height in the denominator decreases, and the two have opposite effects when evaluating net nutrition. BMI variation also depends on when privation occurs, and if an individual is nutrition deprived during early ages, they fail to reach their genetically determined statures and have higher BMIs in later life because there is less physical space to distribute weight. As a result, the use of weight variation over time and by socioeconomic characteristics after controlling for height has become

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[1] There is also concern regarding the use of BMI variation over time because international populations have encountered a modern obesity epidemic, indicating care is used when interpreting BMI variation. However, late 19th and early 20th century females and males were in healthy weight ranges, indicating that 19th century health was not related to BMIs (Carson, 2009; Carson, 2012c; Carson, 2018). Interpreting historical changes in BMI is also different from interpreting modern BMI variation because individuals historically were in lower weight categories compared to their modern counterparts.

a complement to BMI variation (Komlos, 1995; Carson, 2015; Carson, 2016). This study, therefore, uses 19th and early 20th century BMI, height, and weight measures to evaluate net nutritional conditions between women and men with United States during economic development.

Various technological innovations evolved that changed the comparative gender roles within the household (Lunerdini, 1997, pp. 95-96, 143-145; Floud, et al. 2011, pp. 35, 37, and 160), and gender-related technological innovations changed the division of labor within the economy and within the household (Burnette, 2015, p. 224). In traditional agricultural economies because of physical strength, women were less productive than men and found opportunity in early manufacturing industries. During early industrialization, wherever manufacturing spread women's opportunity and wages increased relative to men (Goldin and Sokoloff, 1982; Brands, 2010, p. 106; Bessen, 2015).

Conditions facing women and men in the United States went through various transitions associated with factors beyond technological change and economic development (Lunardini, 1997, pp. 95-96, 143-145). By the late 19th century, political pressures increased to extend legal and political enfranchisement to women. In 1872, Virginia Miner—a leader of the Missouri suffrage movement—attempted to vote in a Saint Louis County election, however, was turned away because she was a woman (Lunardini, 1997, pp. 102-104). She took her case against the Missouri State Registrar, Reese Happersett, to the Missouri state Supreme Court and was denied. In 1874, the case went to the United States Supreme Court in *Miner vs. Happersett*, where the Supreme Court affirmed the Missouri Court's opinion when Chief Justice Morrison A. Waite ruled that the US does not confer the right of suffrage on anyone, and suffrage was not coexistent with citizenship (Lunardini, 1997, p. 103). Various suffrage movements followed advocating for women's political and legal enfranchisement. Carrie Chapman Catt and the National American Suffrage Association (NAWSA) successfully argued that women's efforts during World War I warranted political entrancement. In 1920, the United States' 19th Amendment was ratified, prohibiting states from denying individuals the right to vote based on gender. Nonetheless, the 19th Amendment's effects were slow to materialize in economic and biological conditions.

Table 1, A Comparison between Female and Male BMIs, Height, and Weight

	Period	*Source*	*Complexion*	*Δ Time*	*BMI Δ Centimeter*
Female					
BMI					
Carson (2018a)	1860-1930 Received	US Prisons	Black, .480 Mixed, .403	-2.18	-.134
Height					
Sunder (2011)	1815-1895 Birth	Passport Applications		.060	
Carson (2011)	1810-1890 Birth	US Prisons	Black, -1.45, Mixed, -1.14	.480	
Carson (2013)	1800-1900 Birth	US Prisons	Black, -1.35 Mixed, -1.09	2.63	
Carson (2016)					
Male					
BMI					
Cuff (1993)	1860-1885	West Point Cadets	Whites, .8		
Coclanis and Komlos (1995)	1860-1930	The Citadel	1.7		
Carson, (2009)	1870-1920	Texas Prisoners	Mixed-Race compare to Black, -.334	Blacks, -.40 Whites, .20	Black, -.085 White, -.060
Bodenhorn (2010)	1795-1844	New York Legislators	-1.70		

Carson (2019)	1840-1943	US Prisons	-1.41	Black, 1.13 Mixed-Race .867	Black, -.070 White, -.049
Weight					
Komlos, (1987)	1860-1885	White, West Point Cadets		2.3(lbs.) by birth	
Coclanis and Komlos. (1995)	1870-1930	White 19 year olds, The Citadel		15.6(lbs.)	
Carson (2015)	1840-1920	US Prisons	Black to White, 7.34 Mixed Race to White, 4.98	Black, -9.52 White, -13.33	Black, 3.41(lbs.) White 3.54(lbs.)
Komlos and Carson (2017)	1882-1937	US and McNeil White		-2.49(kg.)	
Carson (2018)	1870-1920	Mexicans in US Prisons		-2.36(lbs.)	3.27(lbs.)
Carson (2020)	1840-1943	US Prisons	Mixed Race to Black -2.01(lbs.)	Black, -7.47(lbs.) White, -11.17(lb.)	Black, 3.38(lbs.) White, 3.58(lbs.)

Source: Carson (2018a); Sunder (2011); Carson, (2011); Carson, (2013); Carson (2016); Cuff (1993); Coclanis and Komlos (1995); Carson (2009a); Bodenhorn, (2010); Carson, (2019); Carson (2015)

Little research exists for late 19th and early 20th century female BMIs, height, and weight and less that compares biological conditions of women and men in similar socioeconomic groups. Women's BMIs in the US varied little over time and stagnated throughout the late 19th and early 20th centuries (Table 1; Carson, 2016; Carson, 2018). After controlling for characteristics, black women had higher BMIs than fairer complexioned mixed-race and white women, and women from the South were taller and had lower BMIs than women from elsewhere within the United States. Nevertheless, women's BMIs did not vary appreciably by socioeconomic status (Carson, 2018). Like women, male BMIs varied little and stagnated throughout the 19th and 20th centuries (Table 1; Carson, 2009; Carson, 2012c). Darker complexioned black men had greater BMIs than fairer complexioned white and mixed-race men, and Southern men had both higher BMIs and taller statures (Carson, 2009; Carson, 2012c; Carson, 2019, pp. 31-32). The inverse relationship between BMI and height was also about twice the magnitude for women as men (Komlos and Carson, 2017; Carson, 2018).

It is against this backdrop that this study considers three paths of inquiry into late 19th and early 20th century women and men's net nutrition. First, how did women and men's BMIs, height, and weight vary over time, and was there a distinguishable break between women and men's net nutrition? Late 19th and early 20th century female and male statures remained constant, and there was no distinguishable break between lower socioeconomic status female and male statures. Second, although women and men held different positions within the household and economy, how did their net nutrition vary by socioeconomic status? Women with no occupations were shorter, and Southern nativity was associated with adequate net nutrition but not to excess, while Southern men with no occupations had both lower BMIs and lower weight than workers in other occupations. Third, how did women and men's historical biological markers vary by nativity and region? White women and men from the South were taller and had lower BMIs; however, lower Southern BMIs do not indicate lower net nutrition because BMI and height are inversely related, and Southerners had lower BMIs because they were taller.

II. Women and Men's Biological Markers and Health

When material measures for living conditions are scarce or unreliable, the use of BMI, height, and weight are now standard economic welfare measures. They are complements to pecuniary measures when monetary and material measures are available. Body mass, height, and weight are also related to various morbidities and mortalities (Waaler, 1984; Koch, 2011; Berrington de Gonzalez, 2010, pp. 2213-2218). For both women and men, mortality risk is minimized for BMIs around 25 (Waaler, 1984; Engeland et al, 2003, pp. 295-296; Berrington de Gonzales, 2010, p. 2214; Floud et al, 2011, pp. 344-347); however, women's mortality risk increases more rapidly than men for BMIs lower or higher than 25 (Fogel, 1994, p. 376). Jee et al. (2006) illustrate a U-shaped relationship between BMI and mortality risk that holds across ethnic groups, while Costa (1993) and Murray (1997) demonstrate the relationship holds historically (Roberts and Steckel, 2019, pp. 327-330). For both women and men, low BMI diseases include infections, sanitation diseases, and tuberculosis (Koch, 2011, Allebeck and Berg, 1992; Andreas et al. 1985; Fogel, 1994; Fogel and Costa, 1997). High BMI diseases include diabetes, heart disease, stroke, and certain cancers (Davey-Smith, 2000, pp. 97-99; Atlas, 2011). Barker (1992) and Schnieder (2017, pp. 4-7) consider the lagged or mis-matched relationship between in-utero conditions and later-life health, and early life conditions are related to long-term health outcomes.

Variation in women's current body weight also has long-term effects on the later life health and cognitive development of her off-spring (Stewart et al, 2015; Prince et al, 2018; Barker, 1992; Sørenson et al. 1997, p. 402; Risnes et al. 2011). Intra-family nutrition and resource allocation were related to household size (Komlos and Carson, 2017; Carson, 2012b; Carson, 2014). In agricultural economies, the benefit of having a child is the expected present value from a child's contribution to household production, less the implicit cost of time devoted to child rearing and explicit costs of resources devoted to child development, which is associated with larger families and internal labor forces (Becker, 1993; p. 305; Carson, 2018, p. 310). For large agricultural households, these costs are lower when older children care for their younger siblings, freeing parental time for agricultural and household production.

Height as a measure for health is related to mortality risk, and Fogel (1994, pp. 377-379) illustrates that male mortality risk is minimized for average statures around 73 inches. Height is inversely related to all-source mortalities, which includes coronary heart disease, stroke, and respiratory mortalities (Davey-Smith et al, 2000, pp. 97-99; Roberts and Steckel, 2019, pp. 327-329; Floud et al, 2011, pp. 369-370). Weaker relationships exist between height and cancers—which includes stomach cancer—and indicates a link between mortality and height (Song et al. 2003). Evaluating 19th and early 20th century women's stature variation also sheds light on cumulative intra-family resource allocation because average stature measures the cumulative net nutrition available to women from their formative years.

Weight after controlling for height reflects current net nutrition and is a complement to BMI variation that does not reflect BMI's mis-matched relationship between weight and height (Schnieder, 2017, pp. 4-7). For modern populations, heavier weight for a given height is associated with diminished health (Berrington de Gonzalez, 2010; Friedrich, 2017; Gregg and Shaw, 2017). However, early weight measures were in healthy categories, indicating that 19th and 20th century weight variation does not represent diminished health that was related to BMI for historical populations (Carson, 2009; Carson, 2012c, Carson, 2019).

III. Late 19th and early 20th Century Female and Male Data

Because the institutions that collected height and weight data were yet to develop, collecting late 19th and early 20th century randomized biological living condition measures is not possible for female and male samples. In the absence of randomly collected data, military records are the most common sources for late 19th and early 20th male century weight and height records, and Fogel et al (1978, p. 456) was the first large-scale attempt using military records to show how net nutrition varied with economic conditions. However, while insightful, military records are more likely to represent conditions among higher socioeconomic groups, that group least sensitive to biological change (Sokoloff and Villaflor, 1982, pp. 456-458; Ellis, 2004, Coclanis and Komlos, 1995, p. 93; Meinzner et al, 2019, p. 239). Prison records are an alternative to military records, and because inmates were more likely to resort to crime to survive, prison records more likely represent conditions among lower socioeconomic groups who were more sensitive to economic change. Because women during the 19th century did not participate in the military, prison records are the main source to evaluate women's historical weight and height (Carson, 2018).

Data used in this study to compare women and men's weight and height is part of an extensive effort to collect and organize biological measures from US prison records. In 1837, Ohio was the first state to construct a separate facility for female inmates, and New York followed in 1839. Female prisoners during the 19th and early 20th centuries were perceived as threats to the moral foundations of society, and during the earliest years of their incarceration, physical and sexual assault within prisons were common (Irwin, 1987; Rafter, 1985). At the time an individual was incarcerated, enumerators recorded gender, weight, height, pre-incarceration occupation, residence, age, occupation, and nativity. Prison records were reported with accuracy because reliable measurements had legal implications in the event an individual escaped and was recaptured. Physical characteristics also helped to identify individuals within prisons. There were 4,592 women and 172,277 men in the prison sample; subsequently, women made up around 2.6 percent of the late 19th and early 20th century prison population.

There are numerous recording concerns with early stature studies, such as whether or not individuals were recorded with or without shoes. Fogel et al (1978) address this concern by comparing military records to a sample of African-American men known to have been measured without shoes and find that there is little difference between the two groups. When measuring BMIs and weight, there is a similar concern for whether individuals were measured with or without clothes. However, given the morays of the time and that women and men were typically measured in the same facilities, it is likely that individuals were measured with clothes. There is also concern whether or not women were pregnant. While there was a comments section in prison registries where women's pregnancy status could be recorded, it was generally not specified. Women in the second and third trimesters were also not typically recorded because they were not in physical conditions to participate in criminal activity to be incarcerated.

Race is inferred from a complexion variable that was recorded at the time an individual was incarcerated and reflects the relationship between race and net nutrition. Women and men of African descent were recorded as black, light black, dark black, and various shades of mulatto. Individuals of European decent were recorded as white, light, medium, and dark. This relationship between white European complexions is supported further because European-born individuals in US prisons were recorded with the same white, light, medium, and dark complexions. In both census and prison records, individuals of combined African and European ancestry were recorded as various shades of 'mulatto.' However, in the results that follow, individuals of mixed African and European ancestry are referred to as ‘mixed-race’ (Carson, 2015a). There are also women and men of Mexican ancestry in US prisons included in this study.

Socioeconomic status is inferred from occupations, and three occupation categories are used to classify socioeconomic status by gender: skilled, unskilled, and workers with no occupation. Bankers, the Clergy, and government administrators are recorded as white-collar workers. Male skilled workers are recorded as butchers, carpenters, and craftsman. Women’s skilled occupations were primarily occupations to serve other women, such as nurses and dressmakers (Goldin, 1990; Burnett, 2013, pp. 306-307; Carson, 2018, p. p. 313). Male unskilled workers are recorded as laborers, cooks, and miners. Female unskilled women were domestic laborers, household laborers, and cooks. A final category is included for individuals who did not report an occupation at the time of measurement. However, caution is used when evaluating women and men’s socioeconomic status based on occupations because occupation distributions have varied with economic, political, and social change (Rosenblum, 2002, p. 88; Church, 2011). Nativity is classified as from the Northeast, Middle Atlantic, Great Lakes, Plains, Southeast, Southwest, and Far West (Carlino and Sill, 2000). Residence is recorded by state of incarceration: Arizona, Colorado, Idaho, Illinois, Kentucky, Missouri, Mississippi, Montana, Nebraska, New Mexico, Oregon, Eastern and Western Pennsylvania, Philadelphia, Tennessee, and Texas.

Table 2, Female and Male Demographics, Socioeconomics, and Observation Period.

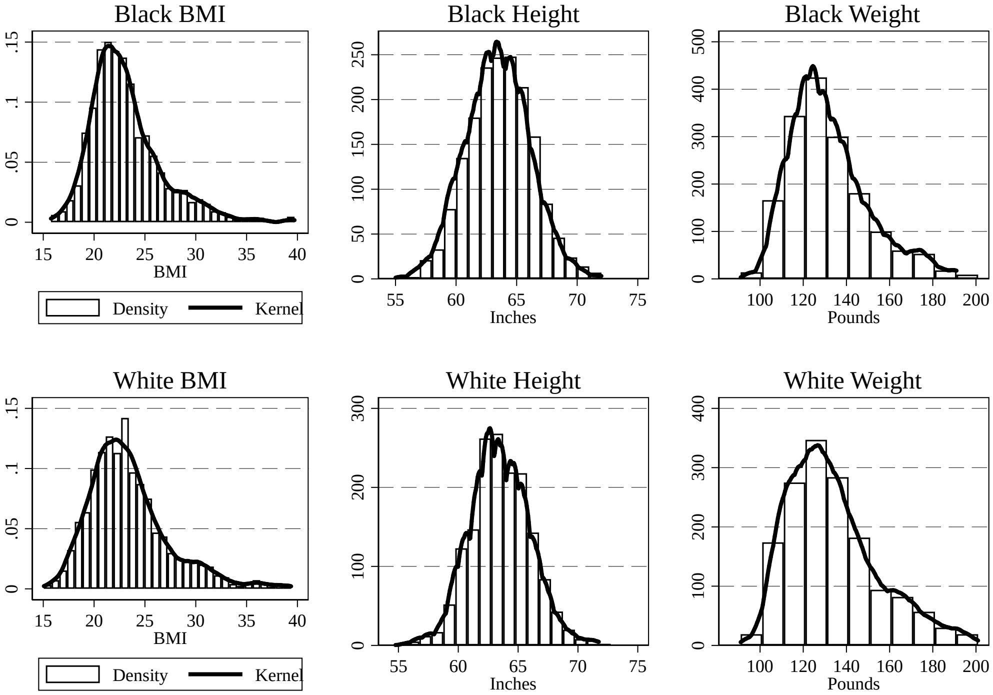
	Females			*Males*	
Race	N	Frequency	**Race**	N	Frequency
Black	1,743	37.96	Black	39,556	22.96
Mexican	85	1.85	Mexican	6,625	3.85
Mixed-Race	1,124	24.48	Mixed-Race	26,131	15.17
White	1,640	35.71	White	99,965	58.03
Ages			**Ages**		
Teens	1,042	22.69	Teens	24,399	14.16
20s	2,166	47.17	20s	87,349	50.70
30s	879	19.14	30s	36,794	21.36
40s	341	7.43	40s	15,446	8.97
50s	123	2.68	50s	6,280	3.65
60s	41	.89	60s	2,009	1.17
Occupations			**Occupations**		
Skilled	409	8.91	Skilled	50,838	29.51
Unskilled	2,967	64.61	Unskilled	96,082	55.77
No Occupations	1,216	26.48	No Occupations	25,357	14.72
Year Received			**Year Received**		
1860s	17	.37	1860s	2,596	1.51
1870s	307	6.69	1870s	14,592	8.47
1880s	848	18.47	1880s	25,348	14.71
1890s	806	17.55	1890s	33,591	19.50
1900s	1,298	28.27	1900s	45,739	26.55
1910s	1,047	22.80	1910s	41,435	24.05
1920s	244	5.31	1920s	6,218	3.61
1930s	25	.54	1930s	2,758	1.60
Native			**Native**		
International			*International*		
Canada	32	.70	Canada	1,578	.92
Europe	141	3.07	Europe	9,347	5.43
Great Britain	172	3.75	Great Britain	5,017	2.91
Latin America	84	1.83	Latin America	6,650	3.86
National			*National*		
Far West	75	1.63	Far West	3,840	2.23
Great Lakes	398	8.67	Great Lakes	15,299	8.88
Middle Atlantic	554	12.06	Middle Atlantic	23,937	13.89
Northeast	18	.39	Northeast	1,944	1.13
Plains	532	11.59	Plains	20,201	11.73
Southeast	1,676	36.50	Southeast	56,302	32.68
Southwest	910	19.82	Southwest	28,162	16.35
Residence			**Residence**		

Arizona	24	.52	Arizona	4,032	2.34
Colorado	301	6.55	Colorado	5,720	3.32
Idaho	12	.26	Idaho	679	.39
Illinois	504	10.98	Illinois	11,314	6.57
Kentucky	120	2.61	Kentucky	11,520	6.69
Missouri	488	10.63	Missouri	19,200	11.14
Mississippi	34	.74	Mississippi	1,698	.99
Montana	85	1.85	Montana	9,033	5.24
Nebraska	112	2.44	Nebraska	7,364	4.27
New Mexico	53	1.15	New Mexico	3,004	1.74
Oregon	3	.07	Oregon	2,189	1.27
PA, East	217	4.76	PA, East	8,961	5.20
PA, West	183	3.99	PA, West	7,684	4.46
Philadelphia	377	8.21	Philadelphia	8,696	5.05
Tennessee	1,029	22.41	Tennessee	28,239	16.39
Texas	1,050	22.87	Texas	42,944	24.93
Total	4,592	100.00		172,277	

Sources: : Arizona State Library, Archives and Public Records, 1700 W. Washington, Phoenix, AZ 85007; Colorado State Archives, 1313 Sherman Street, Room 120, Denver, CO 80203; Idaho State Archives, 2205 Old Penitentiary Road, Boise, Idaho 83712; Illinois State Archives, Margaret Cross Norton Building, Capital Complex, Springfield, IL 62756; Kentucky Department for Libraries and Archives, 300 Coffee Tree Road, Frankfort, KY 40602; Missouri State Archives, 600 West Main Street, Jefferson City, MO 65102; William F. Winter Archives and History Building, 200 North St., Jackson, MS 39201; Montana State Archives, 225 North Roberts, Helena, MT, 59620; Nebraska State Historical Society, 1500 R Street, Lincoln, Nebraska, 68501; New Mexico State Records and Archives, 1205 Camino Carlos Rey, Santa Fe, NM 87507Oregon State Archives, 800 Summer Street, Salem, OR 97310; Pennsylvania Historical and Museum Commission, 350 North Street, Harrisburg, PA 17120; Philadelphia City Archives, 3101 Market Street, Philadelphia, PA 19104; Tennessee State Library and Archives, 403 7th Avenue North, Nashville, TN 37243; Texas State Library and Archives Commission, 1201 Brazos St., Austin TX 78701; Utah State Archives, 346 South Rio Grande Street, Salt

Lake City, UT 84101; Washington State Archives, 1129 Washington Street Southeast, Olympia, WA 98504.

Within the prison sample, women of African-descent were more common than African-American men (Table 2), and black women and men were higher as a percent of the prison population than the general public (Steckel, 2000, Table 10.1, p. 435; Haines, 2000, Table 8.1, p. 306). Black and mixed-race women were the most common female racial category, while white men were the most common male racial category. For both women and men, crimes are committed by the young (Hirschi and Gottfredson, 1983; Gottfredson and Hirschi, 1990; Carson, 2009b; Carson 2018b); however, there were proportionally more young women in the prison sample compared to young men incarcerated as teenagers. During the late 19th and early 20th centuries, there were more individuals with occupations that required greater strength and physical stamina (Goldin, 1990; Burnette, 2013, p. 306; Marquez et al 2019, p. 158; Williams et al, 2019, pp. 298-297; Bleakley and Costa, 2013, pp. 5-10). Furthermore, because they lacked physical strength and sought-after skills, women were foreclosed from skilled occupations and opportunity (Carson, 2009a; Carson, 2018b, p. 313). Women and men were both more likely to be incarcerated in the 1890s, and nativity was more likely to be from the Southeast and Texas.


Black BMI

Black Height

Black Weight

White BMI

White Height

White Weight

Figure 1, Nineteenth and 20th Century Female BMI, Height, and Weight Distributions

Source: See Table 2.

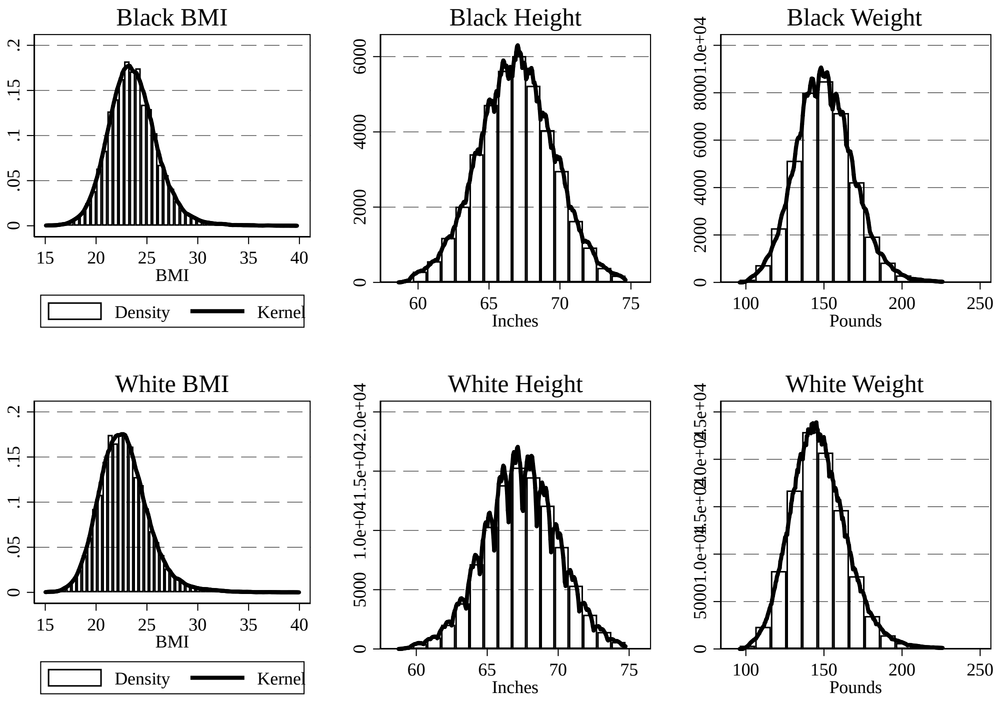


Figure 2, Nineteenth and 20th Century Male BMI, Height, and Weight Distributions

Source: See Table 2.

BMI, height, and weight distributions indicate much about a population's net nutrition. Figures 1 and 2 illustrate that late 19th and early 20th century women and men's height distributions were symmetric. BMI and weight distributions were positively skewed; however, widespread wasting among women and men was not common (Table 2; Figure, 1). White females were both taller and had greater BMIs than black females (Table 2), indicating that during US economic development, lower socioeconomic status African-American women were at a net nutritional and biological disadvantage (Carson, 2018, pp. 316-317). White women's BMIs were more positively skewed with a larger share of white women in higher BMI categories. White males were taller (Carson, 2009b, pp. 150-152); however, black males had higher BMIs and greater weight (Carson, 2009a, p. 123; Carson, 2012c, pp. 377-378; Carson, 2015, pp. 950-952). White and black women's BMIs had larger standard deviations, while white and black men had smaller height standard deviations.

Stature has been used in historical studies to illustrate biological and material inequality (Morodi and Baten, 2005). Nevertheless, the use of stature to measure inequality is limited because it is genetically determined compared to BMI and weight. Moreover, BMI and weight distributions are more plastic and responsive to the immediate effects of material and nutritional variation, therefore, better reflect biological and material inequality.

Table 3, Female-Male BMI, Height, and Weight Inequality

	Women		*Men*	
	CV	Gini	CV	Gini
BMI	.1681	.0880	.1083	.0593
Centimeters	.0433	.0238	.0405	.0226
Kilograms	.1733	.0915	.1255	.0696

Source: See Table 2

To the extent that biological measures represent material welfare and inequality, both women and men's stature Gini Coefficients were more equal than BMI and weight Gini Coefficients (Table 3). Measured by Gini Coefficients, female stature inequality was 6.9 percent more unequal than men. However, stature CV and Gini Coefficients are less representative of the immediate effects of biological inequality. As measured by BMI and weight CVs, women's net nutrition was between 48.3 and 55.2 percent more unequal than men. Consequently, late 19th and early 20th century females had higher BMIs, shorter statures, and greater biological inequality than men.

IV. Female-Male BMI, Height, and Weight Associated with Individual Characteristics

Body mass, height, and weight reflect how a population's net nutrition is affected by personal characteristics. They do not, however, isolate how individual-level characteristics were related to current and cumulative net nutrition. The U-shaped relationship between BMI and mortality risk also complicates interpreting least squares coefficients because least squares coefficients are uni-directional; however, the relationship between BMI and mortality risk is non-linear (Waaler, 1984; Berrington de Gonzalezes, 2010). To evaluate female and male BMIs, multinomial models for underweight, overweight, and obese categories relative to the normal category are used to assess BMI classification, and coefficients are reported as odds ratios (WHO, 1985).[2] Height and weight models are evaluated with least squares.

Body Mass Index

$$\ln\left(\frac{p_j}{p_{Normal}}\right) = \alpha + \beta_c Centimeters_i + \sum_{r=1}^{3}\beta_r Complexion_i + \sum_{a=1}^{10}\beta_a Age_i + \sum_{n=1}^{10}\beta_n Nativity_i$$

$$+\sum_{j=1}^{2}\beta_j Occupation_i + \sum_{t=1}^{7}\beta_t Decade\,\mathrm{Re}\,ceived_i + \beta_l\,\mathrm{Re}\,sidence_i + \varepsilon_i \qquad (1)$$

Height

$$Centimeters_i = \alpha + \sum_{r=1}^{3}\beta_r Complexion_i + \sum_{a=1}^{10}\beta_a Age_i + \sum_{n=1}^{10}\beta_n Nativity_i$$

$$+\sum_{j=1}^{2}\beta_j Occupation_i + \sum_{t=1}^{7}\beta_t Birth\,Decade_i + \beta_l\,\mathrm{Re}\,sidence_i + \varepsilon_i \qquad (2)$$

Weight

$$BMI_i = \alpha + \beta_c Centimeters_i + \sum_{r=1}^{3}\beta_r Complexion_i + \sum_{a=1}^{10}\beta_a Age_i + \sum_{n=1}^{10}\beta_n Nativity_i$$

$$+\sum_{j=1}^{2}\beta_j Occupation_i + \sum_{t=1}^{7}\beta_t Decade\,\mathrm{Re}\,ceived_i + \beta_l\,\mathrm{Re}\,sidence_i + \varepsilon_i \qquad (3)$$

Stature is included in Equation 1 to account for the inverse relationship between BMI and height and in Equation 3 to account for the positive relationship between weight and height

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[2] BMIs less than 18.5 are classified as underweight. Individuals with BMIs between 18.5 and 24.9 are classified as normal weight. BMIs between 24.9 and 29.9 are classified as overweight. Individuals with BMIs over 29.9 are classified as obese.

(Carson, 2009, p. 125; Carson, 2012c, pp. 383-384; Carson, 2018b). Complexion dummy variables are included to account for how women and men’s net nutrition were related to gender and race. Single year youth-age dummy variables are included to account for how net nutrition varied in early life, while adult decade dummy variables are included to account for how BMIs and weight varied in later life. Nativity dummy variables are included to account for cumulative net nutrition since birth. Occupations are included to account for net nutrition variation by socioeconomic status. There are two ways to measure how net nutrition varied over time. Measured since birth, stature reflects how the same cohort experienced net nutritional variation over the life course. Measured in the current period, BMI and weight reflect how different groups encountered net nutritional conditions at the time of measurement (Carson, 2019, pp. 32-33). Birth period variables are included in the stature model to account for how net nutrition varied throughout life by the same cohort. Residence variables are included to account for how net nutrition varied with current condition.

Table 4, Male and Female 19th and Early 20th Century Multinomial BMI Models

	Female			*Male*		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	Underweight	Overweight	Obese	Underweight	Overweight	Obese
Intercept						
Height						
Centimeters	1.05***	.947***	.921***	1..05***	.964***	.892***
Complexion						
White	Reference	Reference	Reference	Reference	Reference	Reference
Black	.500***	1.36**	1.16	.415***	2.32***	1.64***
Mixed-Race	.595**	1.32**	1.27	.551***	1.94***	1.40***
Mexican	1.01	1.19	.687	.917	1.10**	.504***
Age						
14	10.15***	.086**	.402	20.89***	.119***	.248***
15	5.20***	.301**	7.04^{-4}***	9.49***	.126***	.375***
16	1.05	.415***	.106**	5.54***	.184***	.184***
17	1.41	.428***	1.06^{-7}***	2.83***	.292***	.330***
18	1.20	.604***	.364**	1.96***	.408***	.339***
19	.069	.558***	.480*	1.60***	.587***	.535***
20-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	.848	1.51***	3.09***	1.04	1.34***	2.48***
40s	1.00	1.85***	3.89***	1.01	1.59***	4.28***
50s	1.79	2.07***	4.39***	1.19*	1.73***	4.94***
60s	.515	1.22	5.70***	1.85***	1.70***	4.63***
Nativity						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	.671	.327**	.431	1.13	.935	.641**
Great Lakes	.769	.519	.366*	1.00	.991	1.00
Plains	.949	.400	.453	1.00	1.01	.964
Southeast	..714	.443	.272**	1.28	.920	.895
Southwest	.685	.388*	.322*	1.02	.895*	1.05
Far West	1.89	.534	.521	1.12	.883*	.572**
Canada	.373	.266*	.447	1.75**	1.09	.770
Europe	.455	.409	.423	.577***	1.75***	.933
Britain	.618	.619	.089***	.900	.990	.615**
Latin America	.356	.222**	.234	1.01	.733***	.393***
Occupations						
Skilled	1.84**	1.33	2.27**	.859*	1.04	1.46***
Unskilled	1.15	1.12	1.77*	.663***	1.12***	1.04
No Occupations	Reference	Reference	Reference	Reference	Reference	Reference
Received						
1860s	1.69^{-7}***	2.45	6.75**	.595***	1.52***	1.63**
1870s	.834	1.18	2.45***	.842**	1.32***	1.68***

1880s	.721	1.06	.902	.922	1.07***	.829**
1890s	1.18	.930	.929	.818***	1.03*	1.11
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	.967	1.28**	2.45***	1.09*	.929***	1.08
1920s	.723	1.05	2.39***	1.16	.991	1.58***
1930s	1.37	.807	4.02*	1.12	1.09	2.15***
Residence						
Arizona	7.02^{-8}***	2.07	1.99	.667***	.886**	.795
Colorado	.630	1.60**	.618	.435***	1.30***	1.22
Idaho	.991	.970	1.73	.556*	1.06	.771
Illinois	.770	1.08	1.50	.985	.889***	1.78
Kentucky	.656	1.21	.939	1.57***	.772***	.649***
Missouri	.935	1.18	1.32	1.63***	.534***	.520***
Mississippi	.409	1.31	1.94^{-7}***	1.33*	.889*	.520*
Montana	1.24	1.42	1.08	.262***	1.46***	1.43***
Nebraska		1.40	.561	1.45***	.634***	.609***
New Mexico	.623	1.25	8.51^{-8}***	1.20	1.18***	1.36*
Oregon	2.35^{-8}***	1.79	5.45^{-8}***	.450***	1.75***	1.21
PA, East	.578	1.66*	1.50	1.30**	.681***	.833
PA, West	.795	1.90**	1.99*	.390***	1.33***	.870
Philadelphia	1.39	.796	.230**	1.21*	.585***	.555***
Tennessee	.774	.998	1.05	.570***	1.31***	.962
Texas	Reference	Reference	Reference	Reference	Reference	Reference
N	4,592	4,592	4,892	172,277	172,277	172,277
R^2	.0914	.0914	.0914			

Source: See Table 2.

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

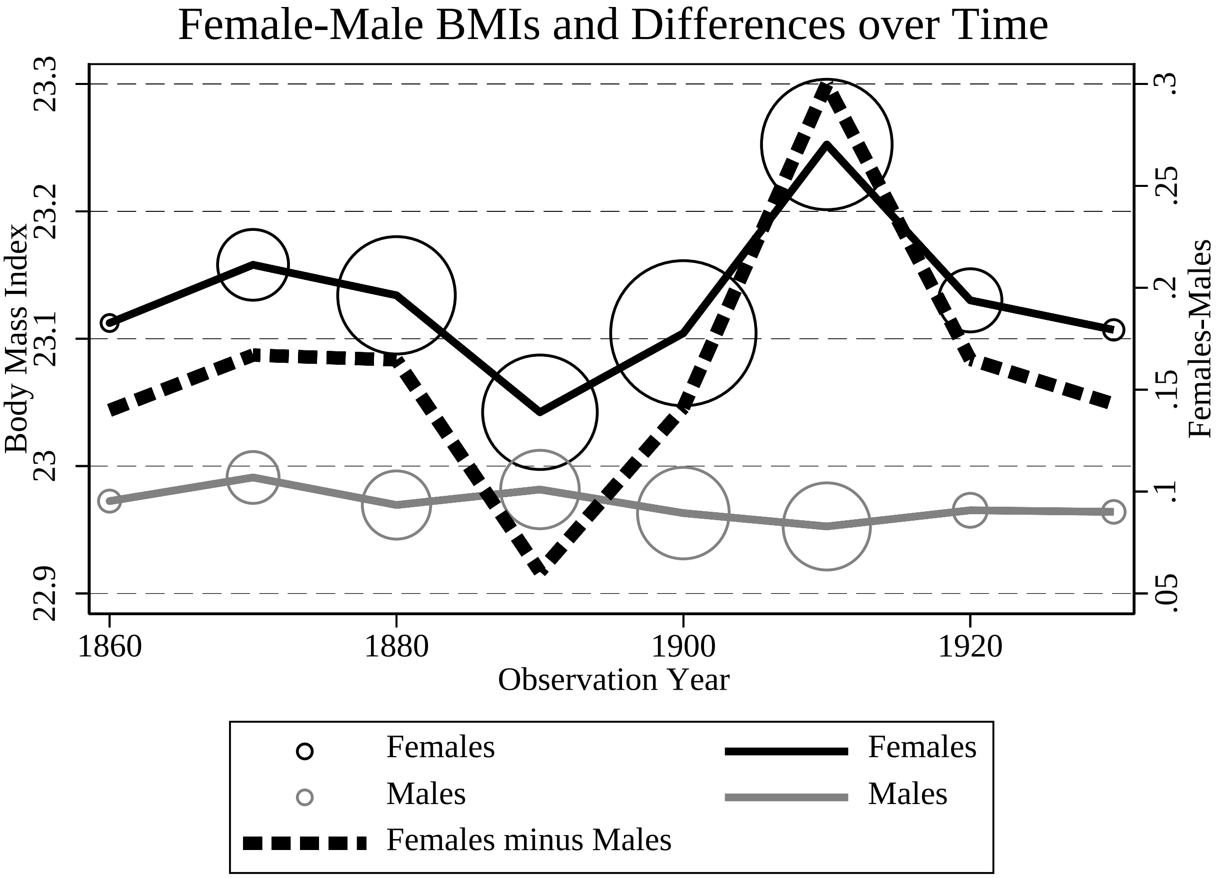

Figure 3, Female-Male Body Mass Index Values over Time

Sources: See Tables 2 and 5.

Note: Circles represent proportional weight. Female and Male average BMIs represented by solid lines.

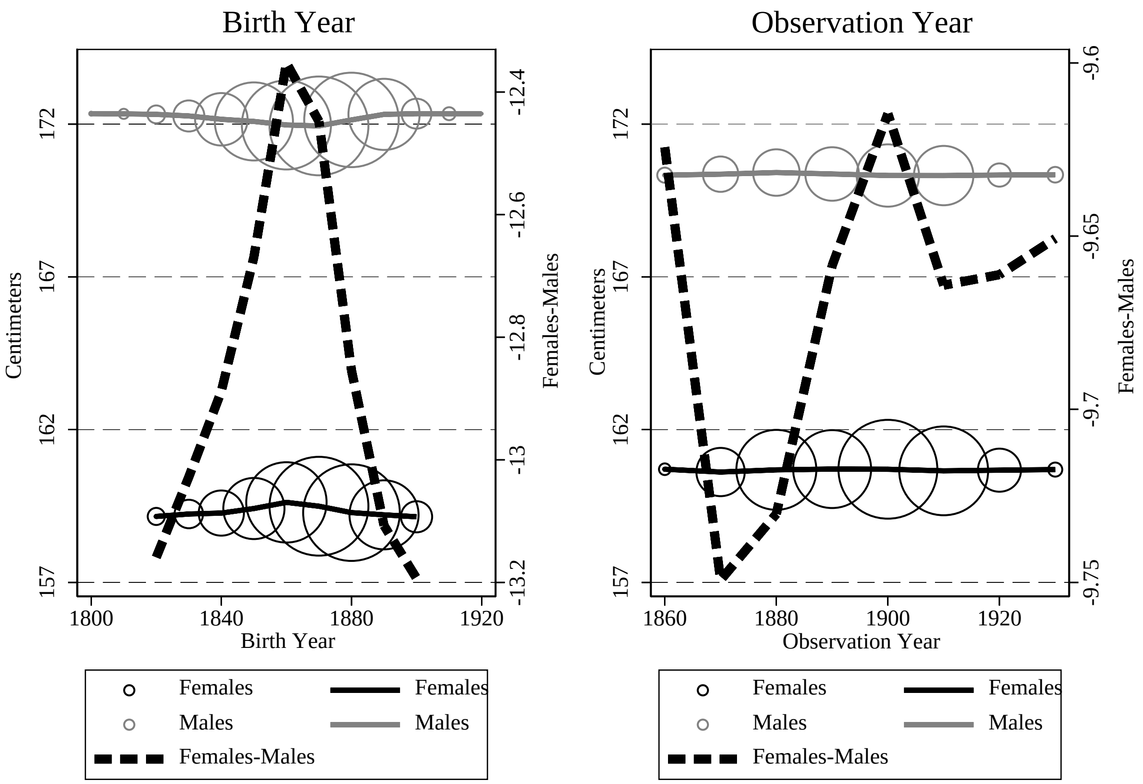

Figure 4, Female-Male Statures over Time

Sources: See Tables 2 and 5.

Note: Circles represent proportional weight. Female and Male average heights in centimeters represented by solid lines.

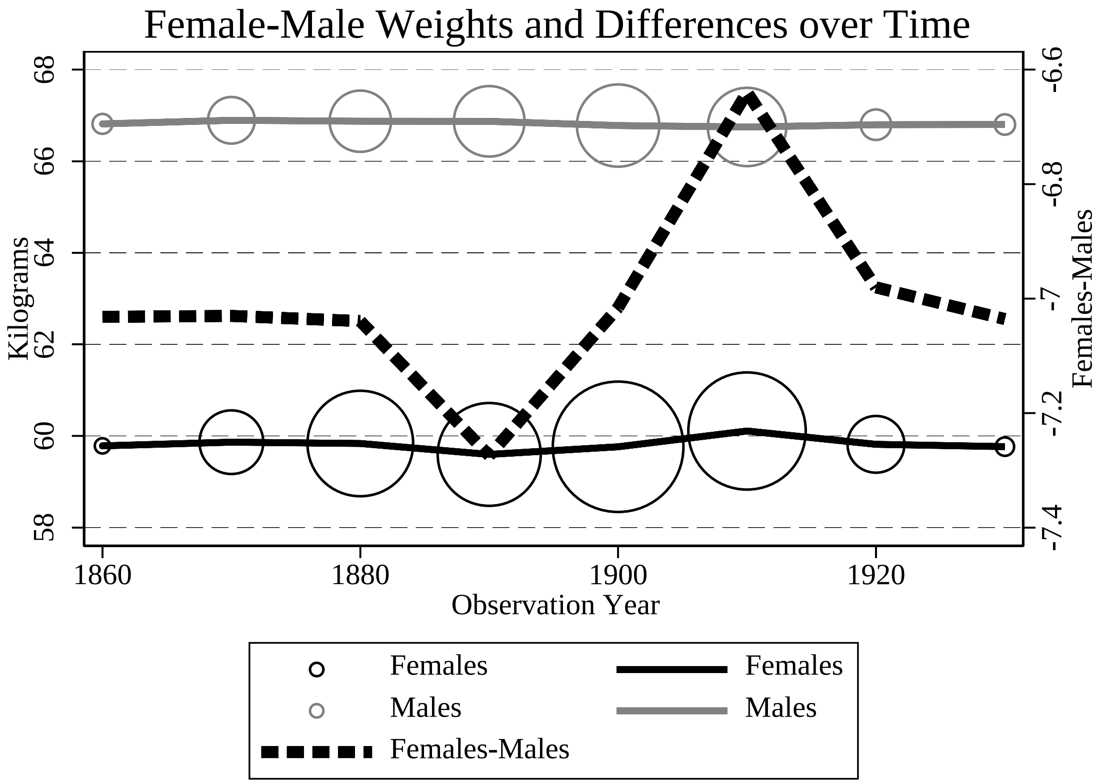

Figure 5, Female-Male Weight over Time

Source: See Tables 2 and 5.

Note: Circles represent proportional weight. Female and Male average weights represented by solid lines.

Three patterns emerge when comparing women and men's net nutritional variation over time. First, a long established pattern in stature studies is the antebellum paradox, where male statures ironically decreased during the 19th century's second and third quarters at the same time that wages and income monotonically increased (Figure 3;Komlos, 1987; Komlos and Carson 2017; Lebergott, 1984; Craig et al. 2014; Bogart, 2009; Carson, 2012a; Carson, 2012b; Carson, 2012c). However, this traditional view has come under scrutiny by Bodenhorn, Mroz, and Guinine (2017), who maintain that height variation is the result of sample selection bias. Nevertheless, this revised view fails to account for interdisciplinary studies that illustrate stature was inversely related to urbanization and industrialization (Meinzer et al, 2019, p. 234; Steckel and Rose, 2002; Davidson et al, 2002; Floud et al. 2011, p. 299; Fogel, 1986, p. 465, Figure 9.1; Sunder, 2011; Fogel et al, 2000, p. 141, Figure 4.1; Komlos and A'Hearn. 2019; Komlos, 2019). Moreover, the antebellum paradox is related to nutrition and disease conditions and not simply stature variation over time (Haines, Craig, and Weiss, 2003; Carson, 2020). While men's BMIs remained stationary over time, women's BMI's varied more than men. Women's BMIs decreased between 1860 and 1890, but had a rapid increase between 1890 and 1910.

Stature measured by birth year demonstrates that males were taller than women because of sexual dimorphism (Figure 4; Gray and Wolfe, 1980; Fray and Wolpoff, 1985), and female statures relative to men by birth year had a sharp increase in the mid-19th century. Komlos (1992) finds that Maryland free black women's height began to decrease early, while Sunder (2011), Carson (2011a), and Carson (2013) show that women's statures increased in the late 19th century (Table 1). Table 3 and Figure 5 indicate that women and men's weight differential remained mostly constant between 1860 and 1880, with a short period of weight decrease in the 1890s, followed by a considerable increase between 1890 and the early 20th century. The female-male average weight differential was the smallest in the 1910s. Consequently, throughout the 19th and 20th centuries, female and male BMIs, statures, and weight variation over time were mostly constant, and there was greater variation in women's net nutrition than men.

Second, female and male BMIs, stature, and weight varied by socioeconomic status, and occupations reflect both net nutrition related to the relative price of nutrition and disease environments (Haines, Craig, and Weiss, 2003; Carson, 2020). Alternatively, occupations reflect physical comparative advantage and occupation choice, where workers with higher BMIs, taller statures, and heavier weights went into physically active occupations because their size gave them an occupational advantage. For example, Margo and Steckel (1992, p. 518) and Steckel and Haurin (1994, pp. 120-122) indicate that workers with taller statures became agricultural workers, where taller statures were required to perform physically active tasks. Because women were not a sufficiently large share of agricultural workers, female and male farmers are excluded from this analysis, and the comparison is between skilled, unskilled, and workers with no occupation. Nonetheless, unskilled occupations were closest to agriculture, and taller unskilled female statures indicate that late 19th and early 20th century unskilled women had better cumulative net nutrition then women in other occupations, whereas greater skilled male BMIs and heavier weights indicate skilled male workers had better current net nutrition. Skilled women were significantly more likely to be both underweight and obese, whereas skilled men were significantly less likely to be underweight and more likely to be obese (Table 3). Skilled women and men received considerably more calories in physically less active occupations than workers with no occupations (Tables 3 and 4). Alternatively, unskilled men were significantly less likely to be underweight and more likely to be overweight than workers with no occupations. Shorter male skilled statures indicates late 19th and early 20th century males in skilled occupations became skilled workers where height and strength were not required.

Third, female and male net nutrition varied by nativity and residence, and women and men from the Northeast and Middle Atlantic were the least likely to be underweight. Northeastern nativity was associated with higher BMIs because they had shorter terminal statures, and BMI is inversely related to height (Carson, 2009; Carson, 2012; Komlos and

Carson, 2017), and greater pollution levels, which deteriorated Northeastern net nutritional conditions (Wilson, 2003; Carson, 2019; Carson, 2012; Komlos and Carson, 2017; Wilson, 2019; Clay et al 2018; Clay et al 2019). Wilson (2003) demonstrates that chronic respiratory diseases were associated with industrialization, urbanization, and pollution, and Bailey et al 2018 show that part of the relationship with deteriorating net nutrition were associated with urban atmospheric pollution, morbidity, and disease (Clay et al 2019; Haines, Craig and Weiss, 2003; Zehetmeyer, 2013, pp. 161, 167, 176, and 184). Alternatively, it was Southern nativity associated with taller female and male statures, which were associated with lower Southern BMIs. The 19th and early 20th century South was agriculturally productive, and agricultural yields exceeded those from elsewhere within the US (Tables 3 and 4; Hilliard, 1972; Ransom and Sutch, 1977, pp. 151-156; Dirks, 2016; Carson, 2010a; Carson, 2011b).

Residence at the time of measurement also reflects current net nutrition related to regional economic conditions. Women's late 19th and early 20th century regional net nutrition was not related to residence at the time of measurement, whereas men's regional net nutrition was higher in the West and lower in the East (Table 4). Physically active men in the West were less likely to be underweight and in normal to overweight categories with taller statures compared to men in the Southwest (Table 3). However, men in the Old South were less likely to be overweight categories and were shorter than individuals in the South and West (Table 3). Men in the Far West had higher BMIs, taller statures, and heavier weights and were more physically active and in close proximity to food production, with fewer communicable diseases (Table 4; Condron and Crimmens, 1983; Carson, 2020), indicating that male net nutrition varied according to local conditions, and men in agriculturally productive areas received nutrition associated with local conditions (Table 4). However, women's net nutrition responded little to local conditions, indicating that males who were more active in market and agricultural activities.

Other patterns are consistent with expectations. Steckel (1979) finds that African-American stature was persistently shorter than fairer complexioned whites, and Bodenhorn (2002) and Steckel (2016, p. 41) suggest the pattern is due to 19th century social preferences that disproportionately favored individuals with fairer complexions. However, if shorter terminal statures were due to social preferences that favored individuals with fairer complexions, white BMIs and weight should have been greater than blacks. Nevertheless, black BMIs and weights were greater than whites for both males and females, indicating that 19th century social preferences are an unlikely explanation for taller 19th century statures (Wilson, 2019, Carson, 2015a; Carson, 2015b).

V. Female and Male Comparative Effects of Demographic, Socioeconomic, and Residence with Individual Biological Measures

Individual characteristics illustrate how net nutrition varied by environmental conditions. They do not, however, indicate how net nutrition varied by structural characteristics and sample compositions. To more fully evaluate how women and men's current and cumulative net nutrition compared throughout the 19th and early 20th centuries, Blinder-Oaxaca decompositions are constructed for female-male BMI, height, and weight differences. In the case of BMI, because women have higher BMIs than men, women are assigned as the base structure (Carson, 2018). Males grow to taller average stature and are assigned the base structure for height decompositions (Gray and Wolfe, 1980; Fray and Wolpoff, 1985), while men are the base structure for weight. α_h and α_l are the autonomous high and low intercepts, and β_h and β_l are the high and low response variable coefficients for how women and men responded to net nutrition. $\overline{X}_h$ and $\overline{X}_l$ are high and low characteristic matrices.

High Response: $$\gamma_h = \alpha_h + \beta_h \overline{X}_h \tag{4}$$

Low Response: $$\gamma_l = \alpha_l + \beta_l \overline{X}_l \tag{5}$$

High and low response variable gaps are explained by the difference between high and low BMIs, heights, and weights.

$$\Delta\gamma = \gamma_h - \gamma_l = \alpha_h + \beta_h \overline{X}_h - \alpha_l - \beta_l \overline{X}_l \tag{6}$$

There are two possible counterfactuals. Net nutrition variables are examined at high response variable returns and low average characteristics (Equation 7), and at low response variable returns at high average characteristics (Equation 8).

$$\beta_h \overline{X}_l - \beta_h \overline{X}_l = 0 \tag{7}$$

$$\beta_l \overline{X}_h - \beta_l \overline{X}_h = 0 \tag{8}$$

Equation 9 is Equation 7 added to Equation 6 and is the biological Oaxaca decomposition for characteristic return differences at low average characteristics at high returns to characteristics.

$$\Delta\gamma = \gamma_h - \gamma_l = \left(\alpha_h - \alpha_l\right) + \left(\beta_h - \beta_l\right)\overline{X}_l + \left(\overline{X}_h - \overline{X}_l\right)\beta_h \tag{9}$$

Equation 10 is Equation 8 added to 6 and is the biological Oaxaca for characteristic differences at low returns to characteristics at high average characteristics.

$$\Delta\gamma = \gamma_h - \gamma_l = \left(\alpha_h - \alpha_l\right) + \left(\beta_h - \beta_l\right)\overline{X}_h + \left(\overline{X}_h - \overline{X}_l\right)\beta_l \tag{10}$$

The first right hand side element for both Equations 9 and 10, are the autonomous differences between high and low BMIs, height, and weight due to non-identifiable factors, such as access to nutrition within the household, income, and wealth (Steckel, 1983; Carson, 2010b). Equations 9 and 10's second right hand side element, $\left(\beta_h - \beta_l\right)\bar{X}_h$, is the share of the net nutrition gap due to differences between high and low returns to structural characteristics. The difference is positive when individuals in the high net nutrition groups had greater returns than the low net nutrition group and negative when the opposite is true. The third right hand side element, $\left(\bar{X}_h - \bar{X}_l\right)\beta_l$, is the share of the gap due to differences between high and low average characteristics. The difference is positive when individuals in the high net nutrition group had greater returns to average characteristics and negative when the low average net nutrition group had greater returns associated with characteristics.

Table 5, Female-Male BMI, Height, and Weight by Demographics, Socioeconomic Status, and Residence

	Female			*Male*		
	Model 1 BMI	**Model 2** Stature	**Model 3** Weight (kg)	**Model 4** BMI	**Model 5** Stature	**Model 6** Weight (kg)
Intercept	43.52***	160.06***	-10.15***	32.61***	174.07***	-40.56***
Height						
Centimeters	-.120***		.456***	-.059***		.623***
Complexion						
White	Reference	Reference	Reference	Reference	Reference	Reference
Black	.521***	-.987***	1.33***	1.11***	-2.27***	3.28***
Mixed-Race	.442***	-1.23***	1.13**	.855***	-1.67***	2.53***
Mexican	-.222	-4.47***	-.816	.071*	-4.27***	.289**
Age						
14	-3.32***	-6.35***	-7.60***	-3.25***	-11.73***	-8.27***
15	-2.71***	-.628	-6.78***	-2.66***	-8.06***	-7.12***
16	-1.36***	-1.94***	-3.43***	-1.99***	-5.22***	-5.49***

17	-1.25***	-.614	-3.16***	-1.36***	-3.15***	-3.84***
18	-.692***	-.566	-1.80***	-1.02***	-1.94***	-2.91***
19	-.564***	.374	-1.53***	-.612***	-1.15***	-1.78***
20-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	1.32***	.569**	3.40***	.328***	.011	.966***
40s	1.73***	-.100	4.49***	.585***	-.614***	1.72***
50s	1.65***	.862	4.27***	.663***	-1.26***	1.92***
60s	1.67***	-.897	4.22**	.559***	-2.11***	1.62***
Nativity						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	-1.78	-1.50	-5.08*	-.097	-.235	-.256
Great Lakes	-1.63	-1.15	-4.68	-.010	.780***	-.004
Plains	-1.75	-1.04	-5.01*	.012	1.20***	.033
Southeast	-2.10**	-.929	-5.91**	-.124**	1.77***	-.366**
Southwest	-1.99*	-.305	-5.66*	-.119*	1.87***	-.362**
Far West	-1.96*	-1.80	-5.61*	-.166**	1.16***	-.503**
Canada	-1.57	-.571	-4.45	-.025	-.463**	-.045
Europe	-.878	-4.19***	-2.80	.710***	2.54***	2.04***
Britain	-1.87*	-1.60	-5.35*	-.017	-1.32***	-.028
Latin America	-2.39**	-3.72**	-6.40**	-.305***	-1.73***	-.854***
Occupations						
Skilled	.303	1.69***	.834	.066***	-.176***	.183***
Unskilled	.215	1.33***	.560	.184***	.059	.515***
No Occupations	Reference	Reference	Reference	Reference	Reference	Reference
Received						
1860s	2.21**		5.38**	.667***		1.94***
1870s	.641***		1.50**	.361***		1.03***
1880s	.149		.386	.082***		.234**
1890s	-.349**		-.950**	.110***		.311***
1900s	Reference		Reference	Reference		Reference
1910s	.623***		1.51***	-.044***		-.128***
1920s	.418		1.01	.087**		.226**
1930s	.267		.538	.155**		.410**
Birth Year						
1800s					Reference	
1810s		Reference			.630	
1820s		.254			-.657	
1830s		.516			-.997	
1840s		1.70			-1.16	
1850s		1.24			-1.29	
1860s		1.59			-1.37	
1870s		1.84			-1.62	
1880s		1.41			-1.92*	

1890s		1.08			-1.73	
1900s		2.51			.373	
1910s					.702	
1920s						
Residence						
Arizona	1.07*	-3.02*	2.45	.040	-2.39***	.192
Colorado	.083	.013	.296	.470***	-1.80***	1.41***
Idaho	1.05	-.370	3.19	.187**	-2.78	.577**
Illinois	.410	-.176	1.11	-.097***	-1.65***	-.235**
Kentucky	.308	-.424	.858	-.432***	-2.18***	-1.22***
Missouri	.278	1.19**	.610	-.741***	-1.72	-2.11***
Mississippi	.449	3.62***	1.09	-.211***	.211	-.667***
Montana	.125	.409	.330	.719***	1.23***	2.18***
Nebraska	-.112	1.11	-.320	-.622***	-.569***	-1.78***
New Mexico	-.455	-.440	-.915	.225***	-.854***	.633***
Oregon	-.236	.187	-.291	.862***	-2.31***	2.58***
PA, East	.586	-2.72***	1.52	-.443***	-3.38***	-1.19***
PA, West	1.16**	-1.07	2.98**	.444***	-2.41***	1.34***
Philadelphia	-1.25***	-.766	-2.99***	-.576***	-2.43***	-1.58***
Tennessee	.197	1.56***	.574	.392***	-2.36***	1.14***
Texas	Reference	Reference	Reference	Reference	Reference	Reference
N	4,592	4,592	4,592	172,277	172,277	172,277
R^2	.1352	.0651	.1937	.1247	.1143	.3532

Source: See Table 2

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

Using coefficients from BMI, height, and weight, decompositions illustrate the source of the female-male net nutrition difference between structural and compositional effects. Table 6 Panel A presents the female-male BMI decompositions, and women had graters BMIs than men. However, the source of net nutritional variation by gender is important. For the BMI proportional intercepts, women had higher BMIs independent of characteristics. Nonetheless, male structural BMI returns to height, race, and nativity offset the female BMI advantage. Women, on the other hand, had greater BMI returns associated with age, residence, occupations, and observation year. Male structural BMI returns were, in general, larger than females, and women's overall BMI advantage was associated with compositional returns to average characteristics rather than returns to characteristics.

Table 6 Female-Male BMI, Height, and Weight Decompositions

BMI	$\left(\beta_f-\beta_m\right)X_m$	$\left(X_f-X_m\right)\beta_f$	$\left(\beta_f-\beta_m\right)X_f$	$\left(X_f-X_m\right)\beta_m$
Level				
Sum	-.692	.941	-.399	.648
Total		.245		.249
Proportion				
Intercept	43.79		43.79	
Height	-41.76	4.67	-39.39	2.30
Race	-.840	.470	-1.33	.982
Ages	1.57	-.742	1.45	-.620
Occupation	.350	-.174	.165	.011
Nativity	-7.27	-.168	-7.37	-.067
Observation Year	.568	-.111	.508	-.051
Residence	.810	-.192	.568	.051
Sum	-2.78	3.78	-1.60	2.60
Total		1		1
Stature	$\left(\beta_m-\beta_f\right)X_f$	$\left(X_m-X_f\right)\beta_m$	$\left(\beta_m-\beta_f\right)X_m$	$\left(X_m-X_f\right)\beta_f$
Level				
Sum	9.15	.793	9.70	2.244
Total		9.94		9.94
Proportion				
Intercept	1.41		1.41	
Race	-.060	.041	-.036	.017
Ages	-.076	.031	-.057	.012
Nativity	.231	-.009	.238	-.016
Occupation	-.099	-.004	-.127	.023
Birth Year	-.304	.003	-.300	-.002
Residence	-.181	.018	-.152	-.011
Sum	.920	.080	.976	.025
Total		1		1
Weight	$\left(\beta_m-\beta_f\right)X_f$	$\left(X_m-X_f\right)\beta_m$	$\left(\beta_m-\beta_f\right)X_m$	$\left(X_m-X_f\right)\beta_f$
Level				
Sum	1.07	5.79	1.88	4.98
Total		6.86		6.86
Proportion				
Intercept	-4.43		-4.43	

Height	3.92	.880	4.15	.643
Race	.161	-.105	.102	-.047
Ages	-.140	.063	-.145	.068
Nativity	.759	.007	.749	.017
Occupation	-.013	.001	-.032	.018
Observation Year	-.039	.005	-.043	.009
Residence	-.056	-.005	-.077	.016
Sum	.156	.844	.275	.725
Total		1		1

Sources: Tables 2 and 5.

Table 6, Panel A, presents male-female stature decompositions, and males had taller statures associated with sexual dimorphism (Gray and Wolfe, 1980; Fray and Wolpoff, 1985). Males had greater stature returns associated with nativity, indicating that regional gender-based practices had long-run net nutrition affects. However, women had greater stature returns associated with birth year, residence, occupations, ages, and race. Male-female compositional differences were small, indicating differences were associated with structural returns to characteristics. Panel C presents male-female weight decompositions, and men had greater weight than females. Nonetheless, like BMI, the source of weight variation was important. Independent of characteristics, females had greater weight than males. However, male weight returns to characteristics offset women’s biological weight advantage. The male weight returns to height and nativity were greater than females, and women had greater weight characteristic returns associated with age, residence, observation year and socioeconomic status. The majority of higher male weights was associated with compositional effects, where men were older and in groups associated with greater weight.

VI. Conclusions

Because wealth obscures how resources are distributed within the household, typical welfare measures during economic development do not account for how material welfare varied by gender between household members and complicates isolating women's net nutrition during economic development. This study shows that female and male BMIs, stature, and weight remained constant throughout the 19th and 20th centuries. Unskilled women and men were significantly less likely to be underweight and male unskilled workers were more likely to be overweight. White women and men from the South were taller and had lower BMIs. Nevertheless, lower Southern BMIs do not indicate lower Southern net nutrition because BMI and height are inversely related, and Southerners had lower BMIs because they were taller. Women's biological measures were ubiquitously more unequal than men. Women had greater BMIs than men independent of characteristics; however, male BMI returns to height were greater than women. Males were taller than females because of sexual dimorphism. Subsequently, women's net nutrition was distributed less equally than men, net nutrition remained constant throughout the late 19th and early 20th centuries, and biological measures provide important insight into how resources were allocated within the household and economy.

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Table 6 Female-Male BMI, Height, and Weight Decompositions

BMI	$\left(\beta_f-\beta_m\right)X_m$	$\left(X_f-X_m\right)\beta_f$	$\left(\beta_f-\beta_m\right)X_f$	$\left(X_f-X_m\right)\beta_m$
Level				
Sum	-.692	.941	-.399	.648
Total		.245		.249
Proportion				
Intercept	43.79		43.79	
Height	-41.76	4.67	-39.39	2.30
Race	-.840	.470	-1.33	.982
Ages	1.57	-.742	1.45	-.620
Occupation	.350	-.174	.165	.011
Nativity	-7.27	-.168	-7.37	-.067
Observation Year	.568	-.111	.508	-.051
Residence	.810	-.192	.568	.051
Sum	-2.78	3.78	-1.60	2.60
Total		1		1
Stature	$\left(\beta_m-\beta_f\right)X_f$	$\left(X_m-X_f\right)\beta_m$	$\left(\beta_m-\beta_f\right)X_m$	$\left(X_m-X_f\right)\beta_f$
Level				
Sum	9.15	.793	9.70	2.244
Total		9.94		9.94
Proportion				
Intercept	1.41		1.41	
Race	-.060	.041	-.036	.017
Ages	-.076	.031	-.057	.012
Nativity	.231	-.009	.238	-.016
Occupation	-.099	-.004	-.127	.023
Birth Year	-.304	.003	-.300	-.002
Residence	-.181	.018	-.152	-.011
Sum	.920	.080	.976	.025
Total		1		1
Weight	$\left(\beta_m-\beta_f\right)X_f$	$\left(X_m-X_f\right)\beta_m$	$\left(\beta_m-\beta_f\right)X_m$	$\left(X_m-X_f\right)\beta_f$
Level				
Sum	1.07	5.79	1.88	4.98
Total		6.86		6.86
Proportion				
Intercept	-4.43		-4.43	
Height	3.92	.880	4.15	.643

Race	.161	-.105	.102	-.047
Ages	-.140	.063	-.145	.068
Nativity	.759	.007	.749	.017
Occupation	-.013	.001	-.032	.018
Observation Year	-.039	.005	-.043	.009
Residence	-.056	-.005	-.077	.016
Sum	.156	.844	.275	.725
Total		1		1

Sources: Tables 2 and 5.