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Abstract

When traditional measures for income and wealth are scarce or unreliable, alternative values are effective in measuring nutritional conditions during economic development. This study uses net nutrition and calories to illustrate that during the 19th and early 20th centuries that men required about 20 percent more calories per day than women. Individuals with darker complexions had greater BMRs and required more calories per day compared to fairer complexioned individuals; however, the difference was not large. Individuals born in the Great Lakes, Plains, and South required more calories per day than individuals from the Northeast and Middle Atlantic. Residence in the developing Northeast and Middle Atlantic was associated with the fewest regional calories per capita. Nineteenth and early 20th century calorie consumption was inversely related to inequality.

JEL-Codes: Q100, Q190, N110, N510.

Keywords: net nutrition, 19th and 20th century gender relations, 19th and 20th century race relations.

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I. Introduction

During the 18th and 19th centuries, the United States was an early destination for Old World immigrants who—in part—sought economic opportunity and improved material welfare (Steckel and Floud, 1997; Carson, 2009; Carson, 2012; Carson, 2016a; Gordon, 2015, pp. 29 and 40; McIntosh, 1995, p. 85; Floud et al, 2011, pp. 297-300). When income and wealth values are scarce or not available, physical activity and calories are two measures that reflect material conditions that are related to demographic and economic characteristics (Carson, 2020; Carson, 2022). Because traditional income and wealth measures fail to account for pollution, environmental conditions, and medical innovations, net nutrition studies are complements to traditional welfare measures when income and wealth are available (Nordhaus, 2003, pp. 10 and 20; Costa and Steckel, 1995; Gordon, 2015, pp. 9-11). A population's average stature measures its cumulative net nutrition, while average body mass and weight measure current net nutrition. A long-standing question in 19th century stature and net nutrition variation are the relative importance of diets versus disease. Komlos (1987) finds that much of 19th century stature decline was due to decreasing net nutrition, while Robert Fogel initially maintained that decreasing weight and height were related to disease and environmental conditions but later revised his views (Floud et al, 2011, p. 318). This study goes one step further and uses height, weight, age, and physical activity to evaluate access to nutrition with calorie equations that provide calorie estimates per capita (Floud et al. 2011, pp. 73, 110, and 315; Harris and Benedict, 1919).

A primary issue when measuring net nutrition is calorie accounting, and there are various ways to measure calories required to sustain a population (Floud et al. 2011, p. 46). For example, consumption surveys, health provider records, military and plantation records, poor house records, and national food balance sheets measure calories available to a population (Floud et al, 2011, pp. 46-49). Another calorie estimation technique is basal metabolic equations multiplied by a physical activity level estimated by socioeconomic status inferred from an individual's age, weight, and height. These calorie equations link physical activity and nutrition to an individual's characteristics, which is not possible with other calorie estimation techniques. This study, therefore, uses contemporary calorie equations to infer 19^{th} and early 20^{th} century calories required to sustain an individual's age, height, weight, and physical activity.

The use of physical measures to infer historical net nutrition has long been used in economic development studies (Fogel et al, 1978; Fogel et al. 1979; Margo and Steckel, 1992; Komlos, 1987; Floud et al. 2011). Like education, nutrition is a form of human capital related to labor market success (Strauss and Thomas, 1998, p. 766; Floud et al. 2011, pp. 21, 22, and 279), and during economic development, nutrition is a valuable measure for material wealth (Komlos, 1987; Costa and Steckel, 1997). Compared to poorly nourished workers, individuals who consume more calories are more productive (Steckel and Floud, 1997; Strauss and Thomas, 1998; Floud et al, 2011, pp. 21, 22, and 279), which is associated with early physical development, and poor health related to nutrition in low-income countries is associated with various health conditions (Strauss and Thomas, 1998, p. 767; Floud et al. 2011; Fogel, 1994, pp. 371-374). For example, high rates of African-American hypertension may be a genetic reaction associated to elevated sodium consumption (McIntosh, 1995, p. 11). Blacks are also more vulnerable to vitamin D related diseases, such as rickets (Kiple and King, 1981, pp. 74-78, 104-116; Carson, 2008a; Carson, 2009).

It is against this backdrop that this study considers three questions regarding 19th and 20th century US net nutrition required to sustain a population by characteristics. First, how did late 19th and early 20th century calories compare by gender? Males required about 567 calories or 20 percent more calories per day than females. Second, how did calories vary by race? Individuals with darker complexions had greater BMRs and required more calories per day relative to fairer complexioned individuals, however, grew to shorter terminal statures. Third, how did calories vary by nativity and residence? Nativity and residence in the developing Northeast and Middle Atlantic were associated with the fewest regional calories per day, with the South and West having the most calories per day.

II. Net Nutrition and Calories from Narrative Histories

Fogel and Engerman (1974) use stature and nutrition to measure material conditions facing 19th century American slaves, who consumed sufficient calories to remain healthy while remaining physically active (Howe, 2007, p. 58). Steckel (1979) uses stature to show that individuals with darker complexions were shorter than individuals with fairer complexions. Margo and Steckel (1983) use stature studies to examine European-American conditions, and farmers and workers from the American South were taller than non-farmers and individuals born elsewhere within the United States. Carson (2009), Carson (2012), and Carson (2015b) show that individuals with darker complexion have heavier weights and higher BMIs. Net nutrition and stature are also related to disease, and the US northeast was more urbanized and had higher disease rates than other regions within the 19th century US (Condran and Cheney, 1982; Condran, Williams, and Cheney, 1987; Haines, Craig and Weiss, 2003; Gordon, 2015, pp. 97-102, and 210; Carson, 2020; Carson, 2022).

Net nutrition and diets are related to changing income and wealth. During economic development, few measures rival net nutrition as a measure for prosperity and material well-being, and US nutrition was a key factor attracting international migrants (McIntosh, 1995, p. 102). In 1870, the US diet compared favorably to international diets (Gordon, 2015, pp. 41, 70, 76), calories were abundant, and there is little evidence of malnutrition (Carson, 2009; Carson, 2012; Gordon, 2015, p. 41; Carson, 2016). Irish potatoes were a staple in the north and central US, while the sweet potato—especially in African-American diets—was dominant in the South (Hilliard, 1972, pp. 174-175; Fogel, 1974 and Engerman, p. 113; Fogel, 1989, pp. 132-136; McIntosh, 1995, p. 82; Gordon, 2015, p. 40). Komlos (1987) finds that per capita meat consumption decreased throughout the 19th century and reduced access to protein (Floud et al 2011, p. 316, footnote 20). In all geographic regions, pork was the most common animal protein (Hilliard, 1972, pp. 92-111; Cuff, 1993; McIntosh, 1995, p. 82; Gordon, 2015, p. 39), and because there were few meat preservation techniques in the early 19th century, salting and smoking were prominent (McIntosh, 1995, pp. 73 and 82; Gordon, 2015, p. 39). However, high sodium used in meat preservation increased hypertension related diseases. During the mid-19th century, a lack of refrigeration and minimal regulation allowed perishable cheese and dairy to deteriorate, and nutrition quality was compromised from unsound preservation techniques (Gordon, 2015, p. 81; McIntosh, 1995, p. 110). Urban diets deteriorated with the separation of food consumption from food production, and milk was whitened and watered to extend dairy production to give the appearance of a healthy dairy products after it began to deteriorate (Carson, 2008b; Gordon, 2015, p. 82; Komlos, 1987; Hooker, 1981, p. 277; McIntosh, 1995, p. 89; Floud et al, 2011).

Various studies examine African and European 19th and 20th century US calories and net nutrition. During the 18th century, British white workers consumed around 2,700 calories per day, while French males consumed 2,400 calories per day (Table 1; Fogel, 1994, p. 372; Fogel and Costa, 1997, p. 52; Floud et al., 2011, pp. 29-31, and 56). Cummings (1940) finds that 19th century US whites consumed 3,741 calories per day. Oren (1973, p. 111) finds that 19th century British working men required between 3,100 and 3,500 calories, and women needed between 2,300 and 2,500 calories per day.[1] Atack and Bateman (1987, p. 210) indicate that white males consumed nearly 5,000 calories per day, which is comparable to a modern robust athlete. Putnam (2000) finds that 19th century white workers consumed 3,000 per day, which is comparable to Carson (2016a) estimates, who finds that 19th and early 20th century white male diets contained 3,032 calories per day. Floud et al, 2011 (p. 34) also find 19th century calories were around 3,00 to 3,100 calories. Nineteenth century male household head diets consumed 3,685 calories (Gordon, 2015, p. 75). These 19th century calories compare to 3,394 calories per day for modern adult US diets, and modern Asian diets are 2,648 calories per day (Foud et al, 2011). The current recommended Daily Allowance (RDA) is 2,200 calories for females and 2,900 for males (Gorille and Gass, 2011, pp. 1 and 2; Glaeser and Cutler, 2021, p. 107).[2]

[1] Pregnant women required about 1,000 more calories per day compared to women who were not pregnant.

[2] Carson (2015c) finds that 19th and early 20th century Mexicans living in the US required around ???? calories per day.

Table 1 Meta Analysis of United States Calories

Author	Publication Date	Sample	Method	Average Calorie
Cumming	1940	White	20th Century	3,741
Oren	1973	British Males	19th Century	3,100-3,500
Oren	1973	British Females	19th Century	2,300-2,500
Fogel and Engerman	1974	Slaves	19th and 20th Century	4,185
Sutch	1976	Slaves	19th Century	3,976
Higgs	1977	Alabama Slaves	19th Century	3,270
Atack and Bateman	1987	White	19th Century	5,000
Fogel	1994	British	18th Century	2,700
Fogel	1994	French	18th Century	2,000
Carson	2014	Black, Adult	19th and 20th Century	3,047
Carson	2014	White, Adult	19th and 20th Century	2,975
Gordon	2015	USDA RDA	1900	3,685
Carson	2015	Mexico, Youth	19th and 20th Century	2,964
Carson	2015	Mexico, Adult	19th and 20th Century	2,904
Gorille and Gass	2011		20th Century Males	2,900
Gorille and Gass	2011		20th Century Females	2,200

Source: Cummings, Richard O. (1940); Oren, Laura. (1973); Fogel, R. & Engerman, S. (1974); Gordon (2015, p. 75); Carson (2015); Gorille and Gass (2011. pp. 1 and 2).

Table 1 illustrates that 19th century calories varied by race, and Fogel and Engermann (1974, pp. 112-113) estimate that black male slaves averaged around 4,200 calories per day. Nineteenth century Alabama average black calories was 3,270 calories per day (Higgs, 1977, p. 107). Reckoning with Fogel and Engermann's calories estimates, Sutch (1976, p. 262) finds that daily male slave calories were around 4,000 calories per day. Carson (2016b) uses calorie equations and finds that 19th century blacks required around 3,050 calories to maintain their physical compositions, which was more calories per day than whites; however, blacks and working-class whites consumed similarly calorie dense diets (Howe, 2007, p. 58). Consequently, late 19th and early 20th century US diets compare favorably to modern African and European diets in the US.

III. Basal Metabolic Rate and Energy Accounting

Calories presented here are imputed from an individual's basal metabolic rate (BMR), which are the daily number of calories required to maintain a body's vital organ function, while at rest, awake, and in a warm climate. The BMR is equivalent to one kilocalorie or the amount of energy required to raise one cubic centimeter of water one degree Celsius, and for 19th century US males, BMRs were between 1,451 and 1,748 calories per day. Nineteenth century average female BMRs were between 1,164 and 1,463 calories. There is a positive relationship between fat-free mass, metabolic rates, and physical activity, and basal metabolic rates are sensitive to muscle mass, and individuals with lean muscle tissue require more calories per day to maintain vital organ function (Poehlman et al. 1988; Poehlman et al 1989; Koshimishu et al 2012; Williams and Woods, 2006; McLannahan and Clifton, 2008, p. 52).[3] To estimate calories, BMRs are multiplied by a physical activity level. There are other factors related to required calories. For instance, calorie privation during one period slows calorie requirements in future periods because the body adapts to fewer calories in the present to require fewer calories in the future (Neel, 1962; Prentice et al. 2005; Prentice et al. 2008; Speakman 2008).

Assessing calories and health during the late 19th and early 20th centuries means estimating historical material conditions. Harrison and Benedict (1919) developed an early method to estimate BMR and calories from physical characteristics, and Mifflin et al (1990)

[3] New debate regarding BMR with age.

equations are used here to measure historical BMRs and calories per day required to maintain a population's weight, height, and physical activity levels (Mifflin et al. 1990; Calofré-Vilà,et al. 2018). Males and females have different percent muscle mass, indicating that different gender equations are required for the relationship between weight, height, and age.

$$BMR_{Male}=5+10\times Weight\ (kgs)+6.25\times Height\ (cms)-5\times Age$$

$$BMR_{Female}=-161+10\times Weight\ (kgs)+6.25\times Height\ (cms)-5\times Age$$

Because calories are estimated from weight and height, some degree of error is expected (Weijs et al, 2007, pp. 153-156). However, Mifflin et al. equations provide reasonable approximations for BMR and calories (Frankenfeld et al. 2005; Floud et al. 2011, p. 314), and the use of calorie equations extends net nutrition studies in a novel direction for stature, body mass, and weight studies. Modern activity levels have decreased, while obesity rates are at record levels (CDC, 2021). However, the majority of late 19^{th} and early 20^{th} century BMIs were in normal to overweight categories, and the normal BMI assumption is important because Mifflin et al equations are for individuals in normal to moderately overweight categories (Mifflin, et al 1990; Carson, 2009; Carson, 2016; Carson, 2019). Estimating calories per day is derived by first imputing daily BMRs from physical characteristics and sorting them by occupations. Imputed occupational-level average BMR values are then standardized by dividing each occupation's average BMR by average laborer's BMRs, which is the physical activity level (PAL). For example, a white collar skilled males PAL is 1.9*.9756 or 1.8537. White collar and skilled imputed BMR values are 1,583.80. Worker's with no listed occupations are 1,604.11.

IV. Data

Data used here to evaluate net nutrition during US economic development is part of a large 19^{th} and early 20^{th} century prison data set to collect and collate US net nutrition during economic development. All state prisons were contacted on multiple occasions, and affordable and available records were entered into a master data set. These prisons include Arizona, Colorado, Idaho, Illinois, Kentucky, Missouri, Mississippi, Montana, Nebraska, Nebraska, New Mexico, Oregon, Eastern Pennsylvania, Western Pennsylvania, Philadelphia, Tennessee, and Texas. Individual characteristics were recorded at the time of entry, therefore, reflect pre-incarceration conditions and not conditions within prisons.

All historical data have potential biases, and military and prison data are the most common sources for 19th and early 20th century weight and height. Military data are for males in sufficiently good health to volunteer or be conscripted. However, conscripted males omit females and overrepresent white males relative to other racial groups (Steckel, 2000; Haines, 2000). To promote military enlistment during low recruiting periods, enlistment requirements may have been relaxed, and shorter individuals may have been included during periods of high conscript demand, whereas when there were plentiful potential conscripts, standards may have been more rigorously enforced (citation ?). Prison records are an alternative to military records and may not be as likely to suffer from these military recording limitations because inmates were admitted for criminal acts and not systematically received on physical charateristics. However, prison records are not above scrutiny, and prisons may have incarcerated many of the materially poorest individuals that represent living conditions among lower socioeconomic groups (Walker, 1988).

Prison enumerators recorded physical and demographic characteristics when individuals were admitted to prisons. Between the 1860s and 1940s, prison enumerators recorded the dates inmates were received, nativity, complexion, age, occupation, height, and weight, and all male and female records with complete values are included in the data set. Because physical measures had implications in the event prisoners escaped and were recaptured, enumerators recorded height and weight with care. Physical descriptions also assisted in identifying individuals within prisons. Because BMR and calories are estimated from weight, height, age, and physical activity recorded at time of admissions, estimated calories from Mifflin et al equations represent calories prior to incarceration.

Prison enumerators were thorough when recording inmate complexion and occupations, and individuals with European ancestry complexions were recorded as white, light, medium, and dark. Individuals of African ancestry were recorded as light black, medium black, dark black, and negro. About one quarter of the prison sample consists of individuals of combined European and African ancestry, who were classified as 'mulatto' in the prison sample. However, in the results that follow, individuals of mixed European and African ancestry are classified as 'mixed race'. Enumerators recorded a broad set of occupations and defined them narrowly, and three occupation classifications are recorded here. Bankers, merchants, and high skilled workers are white-collar workers. Blacksmiths, tailors, and carpenters are skilled workers. About 12 percent of the prison population self-classified as farmers. During the early industrial period, most households were related to agriculture, if only to maintain the household (Church et al, 2011; Rosenbloom, 2002, p. 88; Gordon, 2015, pp. 52-57, and 255). Because there are too few female farmers, occupations are restricted to non-agricultural white-collar and skilled, unskilled, and workers without occupations. A large share of the prison sample was recorded as laborers, miners, and cooks, which are classified as unskilled workers. A final category is classified with no occupation and includes workers with illegible occupations or with no occupations.

Table 2, Late 19th and Early 20th Century Prison Descriptive Statistics

	Frequency	*Percent*		*Frequency*	*Percent*
Gender			**Race**		
Female	4,592	2.60	Black	41,299	23.35
Male	172,277	97.40	Mexican	6,710	3.79
Total	176,869	100.00	Mulatto	27,255	15.41
Residence			White	101,605	57.45
Arizona	4,056	2.29	**Nativity**		
Colorado	6,021	3.40	*United States*		
Idaho	691	.39	Far West	3,915	2.21
Illinois	11,818	6.68	Great Lakes	15,697	8.87
Kentucky	11,640	6.58	Middle Atlantic	24,491	13.85
Missouri	19,688	11.13	Northeast	1,962	1.11
Mississippi	1,732	.98	Plains	20,733	11.72
Montana	9,118	5.16	Southeast	57,978	32.78
Nebraska	7,476	4.23	Southwest	29,072	16.44
New Mexico	3,057	1.73	*International*		
Oregon	2,192	1.24	Canada	1,610	.91
PA, Est	9,178	5.19	Europe	9,488	5.36
PA, West	7,867	4.45	Great Britain	5,189	2.93
Philadelphia	9,073	5.13	Latin America	6,734	3.81
Tennessee	29,268	16.55	**Observation Decade**		
Texas	43,994	24.87	1860s	2,613	1.48
Ages			1870s	14,899	8.42
Teens	25,441	14.38	1880s	26,196	14.81
20s	89.515	50.61	1890s	34,397	19.45
30s	37,673	21.30	1900s	47,037	26.59
40s	15,787	8.93	1910s	42,482	24.02
50s	6,403	3.62	1920s	6,462	3.65
60s	2,050	1.16	1930s	2,783	1.57
Occupations					
No Occupations	26,572	15.02			
Unskilled	99,049	56.00			
White-Collar and Skilled	51,248	28.98			

Source: 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.

Nineteenth century US prison populations were disproportionately male, and most were from the South (Table 2). In historic and modern prison samples, crimes are committed by the young (Hirshchi and Gottfredson, 1983; Gottfreson and Hirshchi, 1990), and over 86 percent of the prison population was younger than 40 years old. There are more workers in the sample listed as unskilled, reflecting young ages and insufficient time in US labor markets to acquire skills. Whites within prisons were more prominent than blacks; however, blacks were overrepresented in the prison population relative to the general population (Haines, 2000; Steckel, 2000). Mexican complexions are also represented in the prison sample. The US-born general population was native to the Northeast and Middle Atlantic. Nearly 50 percent of the prison sample was from the South, and only a small proportion were native to the Northeast and Far West. Most individuals were observed in the 1900s, and prison entry began as early as the 1860s and lasted through the 1930s.

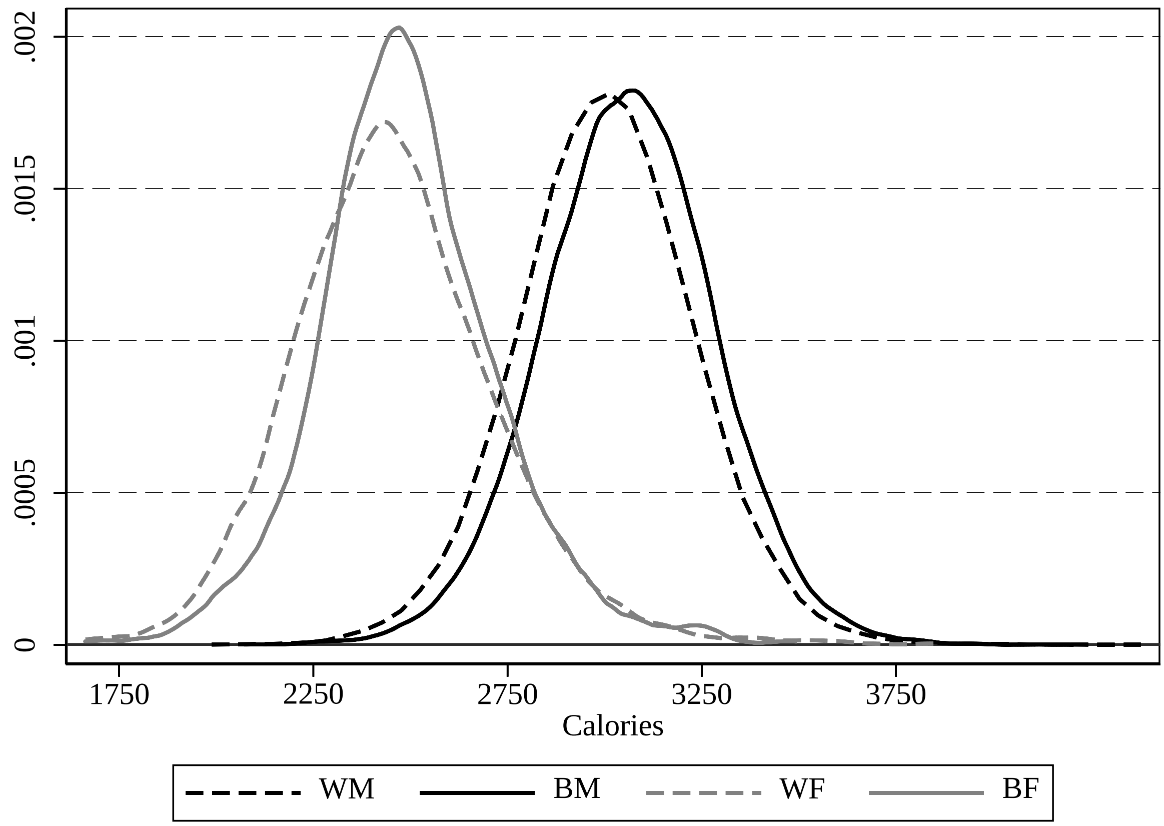

Figure 1, Late 19th and Early 20th Century Black and White, Male and Females Calories per Day

Source: See Table 2.

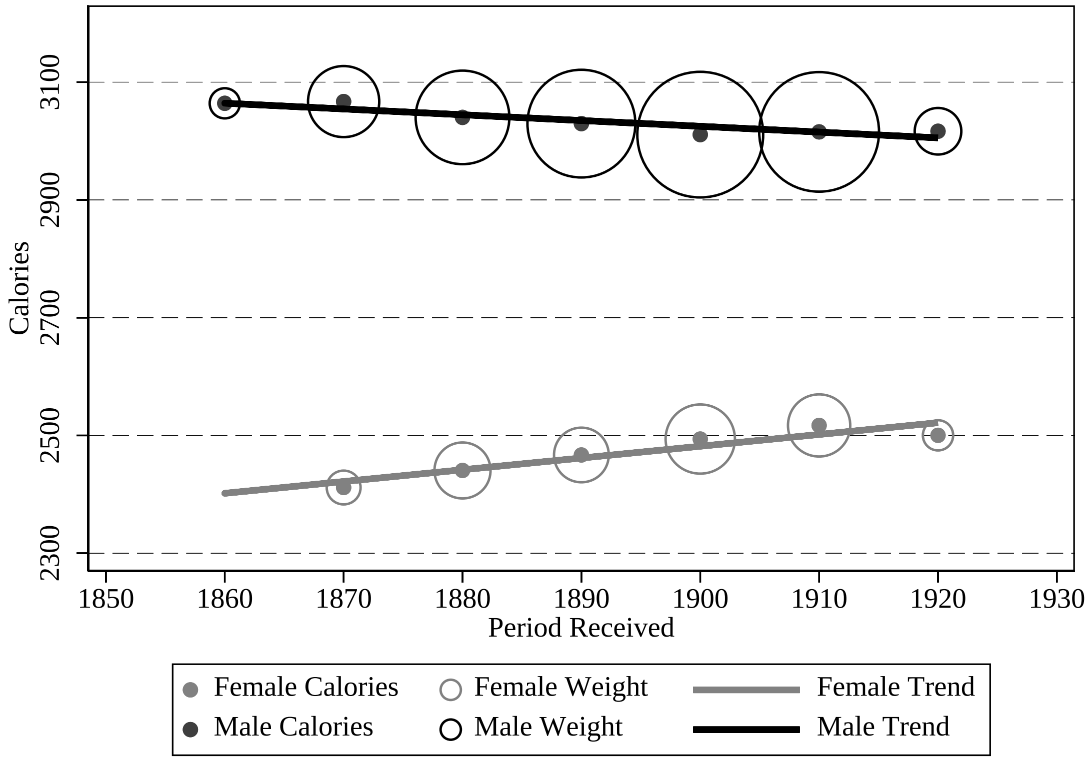

Figure 2, Nineteenth and 20th Century Calories over Time

Source: See Table 2.

Calorie distributions indicate much about a population's net nutrition. Male and female, black and white calorie distributions are presented in Figure 1, and the greatest calorie variation occurs across genders rather than race. Sexual dimorphism is the biological and genetic difference between males and females, and contemporary US males are 9.5 percent taller than females, and male weight is 16.5 percent higher than females (National Health Statistics Report, 2012; United States National Health and Nutrition Examination Survey, 2014). Required male calories per day decreased mildly between 1850 and 1930, while female calories per day increased (Figure 2). From percent muscle mass and sexual dimorphism, 19th and early 20th century black and white males required about 22 percent more calories than females at their peak calories in age. Calories varied by gender, and estimated average black male calories was 3,063, while estimated white male calories was 3,004. Average white female calories was 2,460.61, while average black female calories was 2,495.00 (Carson, 2018). Calories varied by race, and white male calories were 22.11 percent higher than white female calories, while black male calories were about 22.77 percent higher than black female calories. Subsequently, calorie variation is greater by gender than race, and black male calories are 1.96 percent greater than while male calories, while black female calories are 1.42 percent greater than white female calories.

There is a lively debate regarding the relationship between net nutrition, inequality, and health. Wilkinson (1996), Wilkinson and Pickett (2006), Subramanian and Kaswach, (2004), Lynch et al (1998) maintain that net nutrition measures are inversely related to inequality, while Granvelle, (1998) and Deaton (2003, p. 115) hold this inverse relationship is mostly a statistical artifact. Results reported here shed light on this nutrition-inequality debate. A population's net nutrition is related to inequality, and average BMRs, calories, and Gini coefficients are calculated by characteristics (Carson. 2013; Carson and Hodges, 2014). Greater inequality prevents those at the lower end of the social and economic orders from receiving the medical care, health interventions, and net nutrition that increases morbidity and decreases longevity (Martin and Baten, 2005).

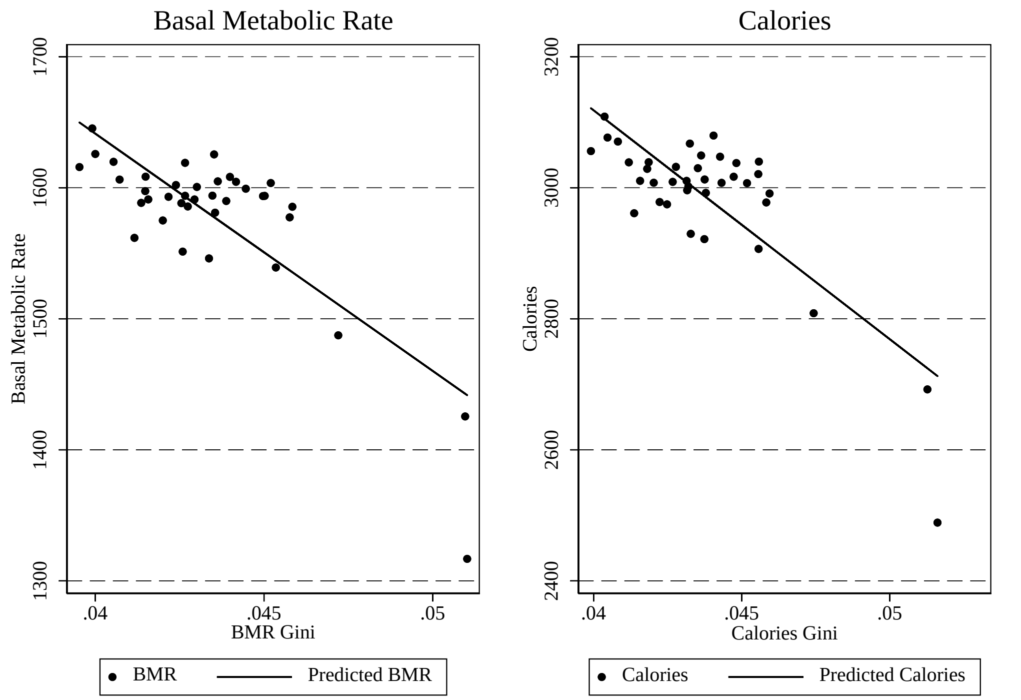

Figure 3, Nineteenth and Early 20th Century Calories and Inequality

Source: See Table 2.

Note: Gini coefficients calculated by characteristics.

Figure 3 shows there is an inverse relationship between 19th and early 20th century average BMR, calories, and inequality. The Gini Coefficient is a measure for inequality that quantifies resource allocation (Floud et al. 2011, p. 94). The 19th and early 20th century white male calorie Gini Coefficient was .0422, whereas the black male calorie Gini Coefficient was .0404. The white female calorie Gini Coefficient was .0581, and the black female calorie Gini Coefficient was .0496, indicating that women's calorie distributions were less equally distributed than males. Throughout the 19th century, rural agriculture was shielded from market development and the deleterious effects of urbanization with inequality, and rural agriculture had greater access to more nutritious diets than other occupations and geographic regions that had greater inequality (Soltow, 1975). Part of this gender-related biological inequality may be related to how women have higher BMIs independent of characteristics. There is also a larger inverse relationship between stature and body mass among women than men (Carson, 2009; Komlos and Carson, 2017, p. 319; Carson, 2018, p. 31).

V. Calories by Gender, Complexion, Age, Occupation, and Demographics

We now test how BMR and calories were related to gender, race, demographics, and socioeconomic status. BMRs and calories are estimated with Mifflin et al equations and assumed to be related to gender, complexion, age, occupations, nativity, residence, and time.

$$BMR_i = \alpha + \beta_F Female_i + \sum_{c=1}^{3} \beta_c Complexion_i + \beta_a Age_i + \sum_{j=2}^{2} \beta_j Occupation_i + \sum_{n=1}^{10} \beta_n Nativity_i$$

$$+ \sum_{r=1}^{15} \beta_r \mathrm{Re}\,sidence_i + \sum_{t=1}^{7} \beta_t Time\,\mathrm{Re}\,ceived_i + \varepsilon_i$$

and

$$Calories_i = \alpha + \beta_F Female_i + \sum_{c=1}^{3} \beta_c Complexion_i + \beta_a Age_i + \sum_{j=2}^{2} \beta_j Occupation_i + \sum_{n=1}^{10} \beta_n Nativity_i$$

$$+ \sum_{r=1}^{15} \beta_r \mathrm{Re}\,sidence_i + \sum_{t=1}^{7} \beta_t Time\,\mathrm{Re}\,ceived_i + \varepsilon_i$$

A female dummy variable is included to assess gender calorie variation. Black, mixed-race, and Mexican race dummy variables are included to determine calorie variation by race. A continuous age variable is included to determine BMR and calorie variation by age. Occupation dummy variables are included to assess nutrition variation by socioeconomic status for skilled and no occupations. National and international nativity dummy variables are included to assess calorie variation since birth. Six residence dummy variables are included to determine calories and net nutrition residence. Time variables are included to account how net nutrition varied over time and net nutrition variation at a point in time.

Table 3, Late 19th and Early 20th Century Calorie Equations by Gender, Demographics, Nativity, Residences and Socioeconomic Status.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
	Total	White	Black	Male	Female	Youth	Adult
Intercept	3,011.58	2,996.78	3,041.79	3,025.77	2,479.56	3,050.93	2,992.96
Gender							
Male	Reference	Reference	Reference			Reference	Reference
Female	.02596	.01614				.03363	.02233
Race							
Black	.23350		Reference	.22961	.37657	.28580	.20874
Mulatto	.15410		.39757	.11961	.24477	.21404	.12572
Mexican	.03794			.03846	.01851	.03472	.03946
White	Reference			Reference	Reference	Reference	Reference
Age	28.470	29.950	26.340	28.540	26.884	19.579	.32.718
Occupation							
White Collar and Skilled	.19703	.26291	.10096	.19920	0	.12190	.22827
Unskilled	Reference	Reference	Reference	Reference	Reference	Reference	Reference
No Occupation	.15024	.09893	.23813	.14719	.26591	.21613	.11904
Nativity							
International							
Canada	.00910	.01448	.00203	.00916	.00697	.00466	.01120
Europe	.05364	.09207	.00168	.05426	.03071	.02652	.06485
Great Britain	.02934	.05045	.00875	.02912	.03746	.01089	.03817
Latin America	.03807	.02224	.00726	.03860	.01829	.02999	.04190
National							

Northeast	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	.13847	.20252	.05678	.13895	.12065	.10990	.15200
Great Lakes	.08875	.13493	.02884	.08881	.08667	.06545	.09979
Plains	.11722	.14723	.08393	.11726	.11585	.11190	.11974
Southeast	.32780	.20196	.54566	.32681	.36498	.38965	.29853
Southwest	.16437	.08296	.26487	.16347	.19817	.22233	.13693
Far West	.02214	.03399	.00511	.02229	.01633	.02254	.02194
Residence							
Arizona	.02293	.03688	.00385	.02340	.00523	.01753	.02549
Colorado	.03404	.05046	.00996	.03320	.06555	.01927	.04104
Idaho	.00391	.00632	.00057	.00394	.00261	.00304	.00432
Illinois	.06682	.09480	.03146	.06567	.10976	.03372	.08249
Kentucky	.06581	.05586	.08700	.06687	.00740	.08269	.05782
Missouri	.11131	.12672	.09899	.11145	.10627	.10581	.11392
Mississippi	.00979	.00271	.02125	.00986	.00740	.01297	.00829
Montana	.05155	.08495	.00667	.05243	.01851	.03280	.06043
Nebraska	.04227	.06263	.01519	.04275	.02439	.02779	.04912
New Mexico	.01728	.01115	.00317	.01744	.01154	.01329	.01912
Oregon	.01239	.02110	.00070	.01271	.00065	.00933	.01385
PA, East	.05189	.04061	.02582	.05202	.04725	.03599	.05942
PA, West	.04448	.06698	.01548	.04460	.03985	.03463	.04914
Philadelphia	.05130	.06722	.03272	.05048	.08210	.04609	.05376
Tennessee	.16548	.09232	.29009	.16392	.22409	.23410	.13299
Texas	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Received							
1860s	.01477	.01587	.01460	.01507	.00370	.02071	.01196
1870s	.08424	.07251	.10687	.08470	.06686	.10251	.07560
1880s	.14811	.13291	.17229	.01471	.18467	.16769	.13884
1890s	.19448	.18078	.20849	.19499	.17552	.20806	.18805
1900s	Reference	Reference	Reference	Reference	Reference	Reference	Reference
1910s	.24019	.25857	.20728	.24081	.22801	.21221	.25343
1920s	.03654	.04724	.02160	.03609	.05314	.02928	.03997
1930s	.01574	.02413	.00438	.01601	.00554	.00644	.02014
N	176,869	101,605	68,554	172.277	4,592	56,826	120,043

Source: See Table 2.

Three general patterns emerge when evaluating 19th and early 20th century female and male BMRs and calories. First, males were physically more active than females, had greater protein in muscle tissue, and required more calories per day than women (Table 2; Kleiner, 1997, p. 145; Guth, 2014). To maintain late 19th and early 20th centuries physical dimension and net nutrition, males required about 567 calories or 20 percent more calories per day than females (Chen, Huq and D'Souza, 1981, p. 61). This calorie comparison is similar to current studies, where males are about nine percent taller and 16 percent heavier than females (National Health Statistics, 2012; NHANES, 2014). However, 19th and 20th century calorie-based gender nutritional inequality is greater than stature and weight differences that may be due to labor arrangements and social custom. For example, when physical strength is a priority during economic development, males were physically more active than females and received greater calorie allocations within the household than men (Table 2; Kleiner, 1997, p. 145; Guth, 2014; Oren, 1973, p. 108-112). In US urban areas, lower socioeconomic status women claimed a disproportionately smaller share of household resources than men. Males consumed greater calorie proportions, and during economic contractions, women received fewer calories (Oren, 1973, pp. 108-112). Moreover, the US 19th century male-female calorie difference for individuals of African and European decent were comparable (Howe, 2007, p. 58), and as calories and material goods became scarcer, the quality of nutrition and calories may have skewed towards men. Consequently, late 19th and early 20th century males required more calories per days than females.

Second, although the difference is small, individuals with darker complexions had greater BMRs and required more calories per day relative to fairer complexioned individuals, and a considerable literature is devoted to explaining the difference (Table 4). Steckel (1979) finds that fairer complexioned whites were taller than blacks, and Carson (2008, p. 823) and Carson (2009, pp. 155-156) illustrate that part of the stature difference was due to biological differences. Modern biology studies also demonstrate that blacks have greater BMIs and muscle mass than whites because blacks have greater percent protein in muscle tissue, and muscle requires more calories per day than fat (Wagner and Heyward, 2000; Guth, 2014). That blacks had shorter statures and required more calories per day is a paradox because more calories per day is associated with taller statures (Fogel and Engerman, 1974, p. 112; Fogel, 1988, pp. 141, 143, and 361). However, 19th and early 20th century blacks required more calories per day and were shorter than whites, indicating that black nutritional requirements were greater than whites. BMRs and calories increased with physical activity, and late 19th and early 20th century blacks were physically more active than whites from early forced labor and later harder work activity from lower socioeconomic status. To keep slaves healthy, slave masters allocated greater calorie allocations to blacks than whites to maintain slave labor productivity, a form of efficiency wages (Atack and Bateman, 1987, p. 210; Fogel and Engerman, 1974, p, 112; Rees et al, 2003). During early emancipation, blacks devoted a higher share of their incomes than whites to acquiring calories (Higgs, 1977, p. 105; Ransom and Sutch 1977, p. 210). After emancipation, blacks were farmers, agricultural laborers, and sharecroppers, and sharecropping was a lower socioeconomic status than farmers and not unique to blacks (Ransom and Sutch, 1977).

Subsequently, greater protein in muscle tissue and greater physical activity supports that individuals with darker complexions required more calories per day than individuals with fairer complexions. Nonetheless while significant, the magnitude of the difference was small.

Third, calories varied by nativity and residence, and individuals born in the Great Lakes, Plains, and South required more calories per day than individuals from the Northeast and Middle Atlantic (McIntosh, 1995, pp. 81-86; Condran and Cheney, 1982; Condran, Williams, and Cheney, 1987). During the late 19th century, Northeastern states were the first to industrialize, and the physical distance between calorie production and consumption increased with industrialization, which affected access to nutrition and physical activity (Komlos, 1987; McIntosh, 1995, pp. 40, 86, and 89; Gordon, 2015, pp. 92-102; Carson, 2008b). Nevertheless, calories required to maintain physical dimensions were higher with US than international nativity, and immigrants from Latin America required the fewest calories per day to sustain shorter statures and lower weights (Kelly, 1947; Lopez-Alanso, 2003; Carson, 2005; Carson, 2007). United States residence at the time of measurement indicates that individuals from Texas required a considerable number of calories to maintain physical dimensions and physical activity in the recently settled west also required more calories per day to maintain physical dimensions. Proximity to local agriculture and feral game allowed individuals in developing US region greater access to calories, which were common in the South and West.

Other patterns are consistent with expectations**.** Individual calories varied over the life course, and more calories were required in the early 20s and diminished thereafter (Table 4; Pontzer et al 2022). Calories varied over the period received, and to the degree calories varied over time, the fewest number of calories were received in the early 1910s. Calories varied by socioeconomic status, and physically active unskilled workers received the most calories per day (Table 3).

IV. Sources of 19th and Early 20th Century Calorie Differences

Dependent variable differences are attributable to returns to characteristics and returns to average characteristics. A Blinder-Oaxaca decomposition is a statistical technique that isolates dependent variable differences into structural and compositional effects (Blinder, 1973; Oaxaca, 1973; Schneewiess, 2011). A difference-in-difference estimator is a quasi-experimental method that isolates causal mechanisms using only observational data (Card and Krueger, 1993). To separate 19th and 20th century black and white calories into structural and compositional effects, a difference-in-difference estimator and Blinder-Oaxaca decomposition are combined to create a difference-in-decomposition estimate. To evaluate the sources of black and white calorie differences, let γ_h and γ_l represent black and white calories by ethnic group. Black calories are the base categories because black calories are higher than white.

$$\gamma_h = \alpha_h + \beta_h X_h$$

and

$$\gamma_l = \alpha_l + \beta_l X_l$$

B_h and β_l are the black and white calorie returns associated with specific stature enhancing characteristics, such as age and occupation. X_h and X_l are black and white characteristic matrices, and black calories are assumed to be the base structure.

$$\Delta C = C_h - C_l = \left(\alpha_h - \alpha_l\right) + \left(\beta_h - \beta_l\right) X_h + \beta_l \left(X_h - X_l\right)$$

and

$$\Delta C = C_h - C_l = (\alpha_h - \alpha_l) + (\beta_h - \beta_l) X_l + \beta_h (X_h - X_l)$$

The second right hand-side element is that component of the calories differential due to characteristics. The third right-hand side element is the part of the calorie differential due to differences in characteristics and is undetermined because whites probably had characteristics associated with greater calorie values, but blacks were shorter.

Table 5, Late 19th and Early 20th Century Gender, Race, and Age Calorie Decompositions

Panel A				
Calories by Gender Levels	Structural $(\beta_m - \beta_f) X_m$	Composition $(X_m - X_f) \beta_f$	Structural $(\beta_m - \beta_f) X_f$	Composition $(X_m - X_f) \beta_m$
Sum	553.66	-5.57	557.79	-9.71
Total		548.08		548.08
Proportions				
Intercept	1.08		1.08	
Complexion	.002	-.005	.003	-.006
Ages	-.0052	-.005	-.058	.001
Occupations	-.002	-4.00^{-4}	.012	-.014
Nativity	.036	4.30^{-4}	.040	-.004
Residence	-.007	.006	-.066	.002
Observation Period	.009	-8.20^{-4}	.006	.003
Migration	-.002	-4.00^{-4}	-.001	-.001
Sum	1.01	-.010	1.02	-.018
Total		1		1
Panel B Calories by Race Levels	$(\beta_b - \beta_w) X_b$	$(X_b - X_w) \beta_w$	$(\beta_b - \beta_w) X_w$	$(X_b - X_w) \beta_b$
Sum	9.62	73.60	-2.44	85.66
Total		83.22		83.22
Proportions				
Intercept	.235		.235	
Ages	-.140	.622	-.165	.648

Occupations	-.004	.094	-.043	.133
Nativity	.023	.116	-.044	.183
Residence	.015	.054	.020	.049
Observation Period	-.012	-.002	-.031	.017
Sum	.116	.884	-.029	1.03
Total		1		1
Panel C Calories by Age Levels	$\left(\beta_a - \beta_y\right) X_a$	$\left(X_a - X_y\right) \beta_y$	$\left(\beta_a - \beta_y\right) X_y$	$\left(X_a - X_y\right) \beta_a$
Sum	394.57	-336.04	-72.63	131.16
Total		58.53		58.53
Proportions				
Intercept	-13.25		-13.25	
Gender	-.007	-.110	-.010	-.106
Complexion	-.159	-.008	-.232	.066
Ages	19.79	-5.93	11.84	2.02
Occupations	-.041	.059	-.056	.073
Nativity	.488	.162	.507	.143
Residence	-.119	.060	-.080	.021
Observation Period	.042	.025	.037	.029
Sum	6.74	-5.74	-1.24	2.24
Total		1		1

Using gender and race calories, male and female black and white differences are decomposed by structural and compositional sources. Panel A illustrates that male calories were greater than females, and after controlling for structural and compositional effects, the primary source of calorie differences is in the autonomous intercepts, indicating that male-female calories and net nutrition differences are due to sexual dimorphism and genetics, not returns to calories or returns to average characteristics. Panel B presents calorie differences by race, and unlike calorie differences by gender, there is greater calorie differences by race by returns to characteristics and returns to average characteristics. Although blacks receive more calories per day, the calorie difference was due less to unobservable effects and more to average characteristics. White calorie returns to age were greater than blacks; however, black calorie returns to average age offset calorie returns to age.

Panel C indicates there were calorie returns by age, and because of the late teen calorie requirement to support growth and fewer calories needed as adults aged, youths required more calories per day than adults. From proportions, the unexplained adult calorie returns were greater than youth calories, indicating that physically active adults required more calories per day than youths. Moreover, youth age returns to calories were greater than adults.

V. Conclusion

When other sources for material welfare are scarce or unreliable, net nutrition is a reasonable alternative to traditional income and wealth measures. Because income and wealth omit important non-priced characteristics, net nutrition measures are valuable complements to income and wealth. Gender related calories reflect conditions within the household and economy, and because of sexual dimorphism, males required considerably more calories per day than females, physical demands from work prior to gender neutral capital, and historical precedent. Beyond race-related physical activity differences associated with chattel slavery, forced labor did not create a large calorie difference between lower socioeconomic status black and whites. Before the introduction of labor-saving devices that were distributed unequally, individuals from both African and European ancestry were both physically active and required similar calories per day. Calories by nativity and residence follow traditional stature and body mass patterns, and individuals native to and residing in rural areas, the South and West required more calories per day than for individuals native to or residing elsewhere in the Unites States.

There was, subsequently, a complex relationship between calories, gender, and complexion, and sexual dimorphism and physical activity explains much of the gender-based calorie difference, while there was less net nutrition variation by race.

References

Alfani, Guido. (2022). "Epidemics, Inequality, and Poverty in Pre-industrial Time." *Journal of Economic Literature, 60(1)*, pp. 3-40.

Atack, Jeremy, Bateman, Fred. 1987. To Their Own Soil: Agriculture in the Antebellum North. Iowa University Press: Ames, IA.

Barondess, David, Nelson, Dorothy, Schlaen, Sandra. 1997. Whole body bone, fat, lean muscle mass in black and white men. Journal of Bone and Mineral Research 12(6). 967-971.

Beacj, Brian, Karen Clay, and Martin Saaveda. (2022). "The 1918 Influenza Pandemic and Its Lessons for Covid-19." *Journal of Economic Literature*, 60(1), pp. 41-84.

Blinder, Alan S. 1973. Wage discrimination: Reduced form and structural estimates. Journal of Human Resources 8: 436–455.

Calofré-Vilà, Gregori, Aravinda Meera Guntupalli, Bernard Harris, and Andrew Hinde (2018).

Card, David and Alan Krueger 1993. "Minimum Wage and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania." *American Economic Review*. 84(4): 772-793.

Carson, Scott Alan. (2005) "The Biological Standard of Living in 19th-Century Mexico and in the American West," *Economics and Human Biology*, Volume 3(3), pp. 405-419.

Carson, Scott Alan. (2006) "The Biological Living Conditions of 19th Century Chinese Males in America," *Journal of Interdisciplinary History*, 37(2), pp. 201-217.

Carson, Scott Alan. (2007a) "Statures of 19th century Chinese males in America," *Annals of Human Biology*, Volume 34(2), pp. 173-182.

Carson, Scott Alan. (2007b) "Mexican Body Mass Index Values in the 19th Century American West," *Economics and Human Biology,* Volume, 5(1), pp. 37-47.

Carson, Scott Alan. (2008a) "The Effect of Geography and Vitamin D on African-American Stature in the 19th Century: Evidence from Prison Records," *Journal of Economic History,* 68(3), pp. 812-830.

Carson, Scott Alan. (2008b) "Health during Industrialization: Evidence from the 19th Century Pennsylvania State Prison System," *Social Science History*. Volume 32(3). pp. 347-372.

Carson, Scott Alan. (2009) "Racial Differences in Body-Mass Indices of Men Imprisoned in 19th Century Texas" *Economics and Human Biology* 7, 1, pp. 121-127.

Carson, Scott Alan. (2012), "The Body Mass Index of Blacks and Whites in the United States during the Nineteenth Century," *Journal of Interdisciplinary History* 42, 3, pp. 371-391.

Carson, Scott Alan. (2013). "Body Mass, Wealth, and Inequality in 19th century U.S. Joining the Debate Surrounding Equality and Health." *Economics and Human Biology* 11(1). pp. 90-94.

Carson, Scott Alan. (2014). "Nineteenth Century US Black and White Working Class Physical Activity and Nutritional Trends during Economic Development." *Journal of Economic Issues,* 48(3), pp. 765-786.

Carson, Scott Alan. (2015a). "The Mexican Calorie Allocation among the Working Class in the 19th Century American West." *Essays in Economic and Business History*. 26, pp. 33-

50.

Carson, Scott Alan. (2015b). "A Weighty Issue: Diminished 19th Century Net Nutrition among the US Working Class." *Demography,* 52, 3, pp. 945-966.

Carson, Scott Alan. (2016a). "Nineteenth Century White Physical Activity, Calories, and Life Expectancy: Nutrition, Sanitation, or Medical Intervention?" *Journal of Interdisciplinary Economics,* 28(2), pp. 168-201.

Carson, Scott Alan. (2016b). "Nineteenth Century Black and Mixed Race Physical Activity, Calories, and Life Expectancy: Nutrition, Sanitation, or Medical Intervention?" *Review of Black Political Economy.* 43, pp. 363-385.

Carson, Scott Alan. (2018). "Black and White Female Body Mass Index Values in the Developing Late 19th and Early 20th Century United States." *Journal of Bioeconomics*, 20(3), pp. 309-330.

Carson, Scott Alan (2019). "Late 19th and Early 20th Century Native and Immigrant Body Mass Index Values in the United States." *Economics and Human Biology*, pp. 26-38.

Carson, Scott Alan (2020). "Net Nutrition, Insolation, Mortality, and the Antebellum Paradox." *Journal of Bioeconomics,* 22, pp. 77-98.

Carson, Scott Alan (2022). "Body Mass, Nutrition, and Disease: 19th Century Current Net Nutrition during Economic Development," *Journal of Bioeconomics*, 24, pp. 37-65.

Carson, Scott Alan and Paul E. Hodges. (2014). "The Relationship between Body Mass, Wealth, and Inequality across the BMI Distribution: Evidence from Nineteenth Century Prison Records." *Mathematical Population Studies* 21(2) pp. 78-94.

Chen, Lincoln, Emdadul Hug, and Stan D'Souza. (1981). "Sex Bias in the Family Allocatioin of Food and Health Care in Rural Bangladesh." *Population and Development Review*, 7(1), pp. 55-70.

Church, T., Thomas, D., Tudor-Locke, C., Katzmarzyk, P., Earnest, C., Rodarte, R., Martin, C., Blair, S., & Bouchard C. (2011). Trends over five decades in U.S. occupation-related physical activity and their associations with obesity. *PlosOne* 6, 5.

Condran, Gretchen A, and Eileen Crimmins. "Public Health Measures and Mortality in U.S. Cities in the Late Nineteenth Century." *Human Ecology*. 6, no. 1 (1978): .

Condran, Gretchen and Eileen Crimmins. "A Description and Evaluation of Mortality Data in the Federal Census: 1850-1900." *Historical Methods.* 12, no. 1 (1979):.

Condran, Gretchen. A. and Rose. A. Cheney. "Mortality Trends in Philadelphia: Age- and Cause-Specific Death Rates, 1870-1930." *Demography.* 19, no. 1 (1982): 97-123.

Condran, Gretchen A., Henry Williams and Rose A. Cheney. "The Decline in Mortality in Philadelphia from 1870 to 1930: the Role of Multiple Services." In *Sickness and Health in America: Readings in the History of Medicine and Public Health, 3rd Ed.* edited by Judith W. Leavitt and Ronald L. Numbers. Madison, WI: University of Wisconsin Press, 1997. 452-466.

Costa, Dora and Richard Steckel. (1997). "Long-Term Trends in Health, Wealth, and Economic Growth in the United States." In: Steckel, Richard and Roderick Floud (Eds.).. *Health and Welfare during Industrialization.*

Chicago: University of Chicago Press. pp. 47-90.

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.

Cummings, Richard O. 1940. *The American and his Food.* Chicago: University of Chicago Press.

Floud, R., Fogel, R., Harris, B., & Hong, S. C. (2011). *The Changing Body: Health, Nutrition, and Human Development.* Cambridge University Press, Cambridge.

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

Fogel, R. & Engerman, S. (1974). *Time on the Cross: The Economics of American Negro Slavery.* Little Brown, New York.

Fogel, Robert W., Engerman, Stanley, Trussell, James, Floud, Roderick, Pope, Clayne, Wimmer, Larry. 1978. The economics of mortality in North America, 1650–1910: A description of a research project. Historical Methods: A Journal of Quantitative and Interdisciplinary History, 11(2), 75-108.

Fogel, Robert. W., Engerman, Stanley, Floud, Roderick, Steckel, Richard, Trussell, James, Wachter, Kenneth Villaflor, Georgia. 1979. The economic and demographic significance of secular changes in human stature: The US 1750-1960. *NBER working paper*.

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

Frankenfield, D, Roth-Yousey, L, Compher, CC. "Comparison of predictive equations for resting metabolic rate in healthy nonobese and obese adults: a systematic review." Journal of the American Dietetic Association. 2005;105(5):775–789.

Glaeser, Edward and David Cutler. (2021). *Survival of the City: Living and Thriving in an Age of Isolation.* New York: Penguin Press.

Gordan, Robert (2015). *The Rise and Fall of American Growth: The US Standard of Living Since the Standard of Living.* Princeton University Press: Princeton.

Gorille, Susan Garner and Saul Gass . (2001). "Stigler's Problem Revisited." *Operations Research*, 49(1), 1-13.

Gottfredson, Michael and Travis Hirschi. *A General Theory of Crime.* Stanford University Press: California. (1990).

Guth, E. Healthy weight loss: there are no magic diets, pills, or operations for long-term, healthy weight loss. *Journal of the American Medical Association.* 2014;312(9), p. 974.

Haines, Michael. "The White Population of the United States, 1790-1920." In *A Population History of North America.* edited by Michael Haines and Richard Steckel. pp. 305-369. Cambridge: Cambridge University Press, 2000.

Haines, Michael, Lee Craig and Thomas Weiss. "The Short and the Dead: Nutrition, Mortality and the "Antebellum Puzzle in the United States," *Journal of Economic History* 63, no. 2, (June 2003): 382-413.

Harris, Arthur and Francis Benedict. 1919. "A Biometric Study of Basal Metabolism in Man." Carnegie Institution of Washington. Washington DC.

Hirshchi, T Gottfredson, M. Age and explanation of crime. *American Journal of Sociology*. 1983;89(3):552-584.

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

Hilliard, Samuel B. 1972. Hog, Meat and Hoecake: Food Supply in the Old South, 1840-1860. Southern Illinois University Press: Carbondale, IL.

Hooker, Richard. (1981). *Food and Drink in America: A History.* Indianappolis: Bobbs-Merrill Company.

Howe, Daniel Walker. (2007). *What Hath God Wrought: The Transformation of America, 1915-1948.* Oxford: Oxford University Press.

Hirshchi, T Gottfredson, M. (1983). "Age and Explanation of Crime." *American Journal of Sociology*. 89(3):552-584.

Kelly, A. R., 1947, Physical Anthropology of a Mexican Population in Texas; a Study in Race-Mixture. Middle American Research Institute, Tulane University of Louisiana: New Orleans, Louisiana.

Kiple, Kenneth and Virginia Kiple, 1977, "Slave Child Mortality: Some Nutritional Answers to a Perennial Puzzle," *Journal of Social History 10*, pp. 284-309.

Kleiner, Susan (1997). "Nutrition for Body Builders." *The Physician and Spots Medicine.* 25(8) pp. 145-146.

Koepke, Nikola, Baten, Joerg. 2005. The biological standard of living in Europe during the last two millennia. European Review of Economic History 9(1), 61-95.

Komlos, J. (1987). The height and weight of West Point cadets: Dietary change in antebellum America. *The Journal of Economic History* 47(4), 897-927.

Komlos, John and Scott Alan Carson. (2017). "The BMI Values of the Lower Classes Likely Declined during the Great Depression." *Economics and Human Biology*, 26, pp. 137-143.

Koshimizu, T, Matsushima, Y, Yokota, Y, Yanagisawa, K, Nagai, S, Okamura, K, Komatsu, Y. Kawahara, T. Basal metabolic rate and body composition of elite Japanese male athletes. Journal of Medical Investigation. 2012;59:253-260.

López-Alonso, M., Condey, R.P., 2003, "The Ups and Downs of Mexican Economic Growth: the Biological Standard of Living and Inequality." *Economics and Human Biology* 1, 169-186.

Lynch, J.W., Kaplan, G., Pamuk, E.R., Cohen, R.D., Heck, C.E., Balfour, J.L., Yen, I., 1998. Income inequality and mortality in metropolitan areas of the United States. American *Journal of Public Health* 88, 1074–1080.

Margo, Robert and Richard Steckel. (1983). "The Heights of Native-Born Whites during the Antebellum Period." *Journal of Economic History* 43(1), pp. 167-174.

Margo, Robert, Steckel, Richard. 1992. The nutrition and health of slaves and antebellum southern whites. In: Fogel Robert, Engerman Stanley. Without Consent or Contract: Conditions of Slave Life and the Transition to Freedom, Technical Papers, Volume 2. pp. 508-521.

Martin, Lisa and Joerg Baten. (2022). "Inequality and Life Expectancy in African and Asia, 1820-2000." *Journal of Economic Behavior and Organization,*201, pp. 40-59.

McIntosh, Elaine. (1995). *American Food Habits in Historical Perspective.* Praeger Publishers:

Westport, CT.

McLannahan, H, Clifton, P. Challenging Obesity: The science behind the Issues. Oxford: Oxford University Press 2008.

Mifflin, MD, St Jeor, ST, Hill, LA, Scott, BJ, Daugherty, SA, Koh, YO. A new predictive equation for resting energy expenditure in healthy individuals. American Journal of Clinical Nutrition, 1990;51:241-247.

National Health Statistics Reports. (2008)."National Health Statistics Reports". 10. 22 October. Accessed: March 31st, 2022.

NHANES. (2004). "United States National Health and Nutrition Examination Survey, 1999-2002" https://www.cdc.gov/nchs/data/ad/ad347.pdf *Accessed: March 31st, 2022.*

Nordhaus, William. (2003). "The Health of Nations: The Contribution of Improved Health of Living Standards." In: Kevin Murphy and Robert Topel. (Eds). *Measuring the Gains from Medical Research.* Chicago: University of Chicago Press. pp. 9-40.

Oaxaca, Ronald, Ransom, Michael. 1999. Identification in detailed wage decompositions. Review of Economics and Statistics 81(1), 154-157.

Oren, Laura. (1973). "The Welfare of Women in Laboring Families: England, 1860-1950." *Feminist Studies* 1(3/4). pp. 107-125.

Poehlman, E, Melby, C, Badylak, S. Resting metabolic rate and post prandial thermogenesis in highly trained and untrained males. American Journal of Clinical Nutrition, 988;47:793-798.

Poehlman, E, Melby, C, Badylak S, Calles, J. Aerobic fitness and resting energy expenditures in young adult males. Metabolism. 1989;38:85-90.

Pontzer , Herman, Yosuke Yamada, Hiroyuki Sagayama, Philip N Ainslie, Lene F Andersen , Liam J Anderson, Lenore Arab , Issaad Baddou , Kweku Bedu-Addo , Ellen E Blaak , Stephane Blanc, Alberto G Bonomi , Carlijn V C Bouten , Pascal Bovet , Maciej S Buchowski, Nancy F Butte, Stefan G Camps, Graeme L Close, Jamie A Cooper, Richard Cooper, Sai Krupa Das, Lara R Dugas, Ulf Ekelund, Sonja Entringer, Terrence Forrester, Barry W Fudge, Annelies H Goris, Michael Gurven, Catherine Hambly, Asmaa El Hamdouchi, Marjije B Hoos, Sumei Hu, Noorjehan Joonas, Annemiek M Joosen, Peter Katzmarzyk, Kitty P Kempen, Misaka Kimura, William E Kraus, Robert F Kushner, Estelle V Lambert, William R Leonard, Nader Lessan, Corby Martin, Anine C Medin, Erwin P Meijer, James C Morehen, James P Morton, Marian L Neuhouser, Teresa A Nicklas, Robert M Ojiambo, Kirsi H Pietiläinen, Yannis P Pitsiladis, Jacob Plange-Rhule, Guy Plasqui, Ross L Prentice, Roberto A Rabinovich, Susan B Racette, David A Raichlen, Eric Ravussin, Rebecca M Reynolds, Susan B Roberts, Albertine J Schuit, Anders M Sjödin, Eric Stice, Samuel S Urlacher, Giulio Valenti, Ludo M Van Etten, Edgar A Van Mil, Jonathan C K Wells, George Wilson, Brian M Wood, Jack Yanovski, Tsukasa Yoshida, Xueying Zhang, Alexia J Murphy-Alford, Cornelia Loechl, Amy H Luke, Jennifer Rood, Dale A Schoeller, Klaas R Westerterp, William W Wong, John R Speakman. "Daily Energy Expenditure through the Human Life Course. *Science.*

Prentice, AM, Starvation in humans: evolutionary background and contemporary implications. Mechanisms of aging and development 2005;126(9):976-981.

Prentice, AM, Hennig, BJ, Fulford AJ. Evolutionary origins of the obesity epidemic: natural selection of thrifty genes or genetic drift fallowing predation release? International Journal of Obesity. 2008;32(11):1607-1610.

Putnam, Judy 2000. "Major Trends in U.S. Food Supply, 1909-1999." *Food Review*. 23(1), pp. 8-15).

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.

Rosenbloom, J. Looking for Work: Searching for Workers. Cambridge: Cambridge University Press. 2002.

Schneeweis, Nicol. 2011. Educational institutions and integration of immigrants. Journal of Population Economics, 24(4), 1281-1308.

Soltow, L., 1975. Men and Wealth in the United States, 1850–1870. Yale University Press: New Haven.

Speakman, JR. Thrifty genes for obesity, an attractive but flawed idea, and an alternative perspective: the 'thrifty gene' hypothesis. International Journal of Obesity. 2008;32 (11):1611-1617.

Speakman, JR, Selman, C. Physical activity and resting metabolic rate. Proceedings of the nutritional society. 2003;62:621-630.

Steckel, Richard. "Slave Height Profiles from Coastwise Manifests." *Explorations in Economic History* 16 (1979): 363-380.

Steckel, Richard. (2000). "The African American Population of the United States, 1790-1920." In *A Population History of North America.* edited by Michael Haines and Richard Steckel. Cambridge: Cambridge University Press, 2000.

Steckel, Richard. (2008). "Biological Measures of the Standard of Living." *Journal of Economic*

Perspectives 22(1), pp. 129-152.

Steckel, Richard and Roderick Floud (1997). *Health and Welfare during Industrialization.* Chicago: University of Chicago Press.

Strauss, John and Duncan Thomas. (1998) “Health, Nutrition, and Economic Development.” *Journal of Economic Literature.* pp. 766-817.

Subramanian, S.V., Kawachi, I., 2004. Income inequality and health: what have we learned so far? Epidemiological Reviews 26, 78–91.

Sutch, R. Care and feeding of slaves. In: David, P, Gutman, H, Stutch, R, Temin, P, Wright, G. editors. Reckoning with Slavery. Oxford: Oxford University Press. 1976. pp. 231-301.

Wagner, DR, Heyward VH,. Measures of composition in blacks and whites: a comparative review. American Journal of Clinical Nutrition. 2000;71:1392-1402.

Weijs, P, Hinke M. Kruisenga, A. van Dijk, van der Meij, B, Langius, J. Knol, D, van Schijndel. R. Validation of predictive equations for resting energy expenditure in adult outpatients and inpatients. Clinical Nutrition. 2008;27(1):150-157.

Wilkinson, R.G., 1996. Unhealthy Societies: The Effects of Inequality. Rutledge, New York.

Wilkinson, R.G., Pickett, K.E., 2006. Income inequality and population health: a review and explanation of the evidence. Social Science and Medicine 62, 1768–1784.

Wilkinson, R.G., Pickett, K.E., 2009. The Spirit Level: Why Greate Makes Societies Stronger. Bloomsbury Press, New York.

Williams, PT, Wood, PD. The effects of changing exercise levels on weight and age-related weight. International Journal of Obesity. 2006;30(3):543-551.