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Abstract

In 1893, Frederick Jackson Turner proposed that America's Western frontier was an economic 'safety-valve,' a place where settlers could migrate when conditions in eastern states and Europe crystalized against their upward economic mobility. However, recent studies suggest the Western frontier's material conditions may not have been as advantageous as Jackson proposed because settlers lacked the knowledge and human capital to succeed on the Plains and Far Western frontier. This study illustrates that current and cumulative net nutrition on the Central Plains improved during the late 19th and early 20th centuries, indicating that recent challenges to the Turner hypothesis are not well supported by net nutrition studies. Net nutrition improve with agricultural innovations and biotechnologies on the western frontier, and rural agricultural workers net nutrition was better than from elsewhere within the US.

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

Keywords: nineteenth century black and white stature variation, urbanization, US Central Plains.

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I. Introduction

In 1893, Frederick Jackson Turner proposed that America's western frontier was a 'safety-value,' a place where immigrants relocated when conditions in eastern states and Europe crystalized against their upward economic and social mobility (Turner, 1893; Turner, 1920, p. 277-280; Senning et al. 1914, pp. 11-13). However, as seminal hypotheses must endure, because settlers were slow to adjust their farm sizes, adjust to changing weather patterns, and acquire necessary region-specific human capital, the Turner hypothesis has come under recent scrutiny from studies that suggest conditions on the Central Plains deteriorated with economic development (Libecap and Hansen, 2002, pp. 87-88; Hansen and Labecap, 2004, pp. 670-674, 686; Hansen and Libecap, 2204, p. 127). Turner's hypothesis addresses material conditions; however, net nutrition and disease go through various transitions that reflect economic and biological conditions. Net nutrition on the Central Plains varied with agricultural productivity, technological innovations, and large in-migrations from eastern states and Europe. This study, therefore, uses late 19th and early 20th century Central Plains' net nutrition to assess whether the Turner hypothesis is robust with respect to net nutrition and shows that recent challenges to economic development on the western frontier are not well supported by biological measures.

Stature reflects the net cumulative difference between calories consumed and calories required for work and to withstand the physical environment (Fogel et. 1979). The body mass index (BMI) is weight in kilograms divided by height in meters squared and may reflect net current changes in the same variables (Fogel, 1994). However, interpreting BMI variation is more problematic than interpreting stature variation because BMI is the ratio of current to cumulative net nutrition, and the two have opposite effects when evaluating net nutrition (Carson, 2015c). For example, BMIs are high when weight in the numerator is high or height in the denominator is low, yet shorter statures reflect poor net nutrition. Moreover, an individual who receives insufficient nutrition in their youth reaches shorter statures with lower metabolisms, and have higher BMIs in later life (Mifflin et al. 1990; Schnieder, 2017). As the ratio of weight to height, BMI represents the lagged or mismatched effect of the timing of privation and may not be as good of measure for current net nutrition as weight after controlling for height (Gluckman and Hanson, 2006, p. 10; Carson, 2015b; Schnieder, 2017, p. 7; Carson, 2017). Subsequently, BMI is an established measure for mortality risk, whereas weight after controlling for height is an alternative measure for current net nutrition. Body mass is related to health (Waaler, 1984), and life expectancy is lower and mortality risk higher for BMIs below 18.5. Life expectancy is high and mortality risk low for BMIs between 18.5 and 27 but increases for BMIs above 27 (Fogel, 1994, pp. 375-377; Koch, 2011). Costa (1993) shows Waaler's results hold for historical populations, and Jee et al. (2006, pp. 780, 785-786) demonstrate the relationship is similar across ethnic status. Body mass, height, and weight also vary with economic development, and each are used here to assess late 19th and early 20th century net nutrition on the Central Plains (Cochrane, 1979, pp. 24-32, 69-77; Carson, 2013; Dirks, 2016; Zahetmeyer, 2013).

The Central Plains is important in economic studies because various elements prevailed simultaneously as development occurred. The antebellum paradox is the proposition that average statures decreased during the 19th century's second and third quarters at the same time that wages and incomes monotonically increased (Bogart, 2009; Libergott, 1984; Komlos, 1987; Olmstead and Rhode, 2006, Tables, Da24 and Da25; Atack et al. 2000, p. 261). Geographic regions within the US developed at uneven rates, and because eastern states and Europe developed before the Central Plains, their net nutrition, stature, and BMIs experienced disproportionate biological stress compared to other regions within the US. Alternatively, as agricultural conditions improved, net nutrition on the Central Plains may have improved with economic development technologies took root, and the agricultural sectors became more efficient with scale (Atack et al. 2000, p. 261; Olmstead and Rhose, 2006, Tables Da24 and Da25; Carson, 2010). Political and social developments were related to conditions in the real economy, and four broad explanations are offered to explain the net nutritional deterioration in the late 19th and early 20th centuries (Haines, 2004, pp. 251-252): a transportation revolution and accompanying agricultural commercialization; a growing dependence on wage labor at the same time that wealth and income inequality increased; a deteriorating disease environment (Komlos, 1987; McGuire and Coelho, 2000; Steckel, 2000; McGuire and Coelho, 2011); and rapid urbanization that was not accompanied by a corresponding growth in public health and sanitation systems (Ferrie and Troesken, 2008). Therefore, the Central Plains is an ideal environment to assess the relative effects of nutritional stress during economic development.

It is against this backdrop that this study considers three paths of inquiry into late 19th and early 20th century net nutrition and health on the Central Plains. First, as the Central Plains received considerable in-migration from eastern states and Europe, how did net nutrition vary overtime as agricultural technology improved and markets developed? Body mass, height, and weight increased throughout the late 19th and early 20th centuries, indicating that recent challenges to the Turner hypothesis are not well supported on the Central Plains. Second, during this period of rapid economic change, how did current net nutrition vary by socioeconomic status? After accounting for selection, farmers and ranchers had greater BMIs, taller statures, and heavier weights than workers in other occupations. Third, how did African-American, mixed-race, and white net nutrition compare in this geographic region where free-labor was the primary labor force? As it did throughout the US, individuals with darker complexions had higher BMIs than mixed-race and white individuals, indicating that a late 19th and early 20th century BMI 'mulatto advantage' did not exist among the Great Plain's working class.

II. Economic Development on the Central Plains

The Central Plains is the flatland prairie that lies west of the Mississippi River and east of the Rocky Mountains. The region was acquired with the Louisiana Purchase when Napoleon and France—desperate for cash—sold their New World interests to the Jefferson Administration and young United States. The region's distinct economic characteristics were its size, central river basins, military expeditions, and location within the US. The Missouri and Mississippi River Basins were fundamental to the Central Plain's economic development. Originating in Montana's Rocky Mountains, the Missouri flows east across Wyoming, Colorado, the Dakotas, and Nebraska to drain into the Mississippi just north of Saint Louis. The Mississippi is North America's longest river, originates in Minnesota, and affects 40 percent of North America's water drainage from 31 states before emptying into the Gulf of Mexico. In combination, the Missouri and Mississippi rivers defined much of the 19th century Central Plains' geography, economic development, and were used as low-cost transportation networks to transport goods and peoples to the US interior (US Bureau of the Census, 1975; Taylor, 1962).

Between 1804 and 1806, Thomas Jefferson sent explorers Merriweather Lewis and William Clark to explore the Missouri River Basin and find the Northwest Passage to the Pacific. French-Canadian trappers were the first Europeans to inhabit the Mississippi River Basin and used the rivers as a low cost transportation route to ship their furs to eastern states and European markets. An important part of US transportation and agriculture, the Central Plains is divided into tall, mixed, and short grass prairies. Tall grass prairies receive between 30 and 35 inches of rainfall per year. Rich in plant cover, these tall grass prairies once had grasses that reached two meters in height; however, with economic development, few of these tall grass prairies remain. These tall-grass prairies sustained millions of American Bison, and with this mobile protein source, was home to numerous indigenous groups and later domesticated cattle (Steckel and Prince, 2001; Prince and Steckel, 2003). Central Plain's mixed-grass prairies lie to the west of tall grass prairies, receive between 20 and 25 inches of rainfall per year, and were settled with small household farms that supported wheat and corn production (Atack and Bateman, 1987; Olmstead and Rhode, 2006, Tables Da24 and Da25; Olmstead and Rhode, 2008, pp. 17-97). Further to the West, short grasses dominate and precipitation decreases to less than 20 inches per year, and during the late 19th century, the western Central Plains supported large beef producing enterprises. These prairie grasslands created a productive agricultural region that specialized in wheat and corn production but were self-sustaining and created surpluses in beef and animal proteins (Olmstead and Rhodes, 2008; Atack and Bateman, 1987; Atack et al. 2000, p. 261).

For most of the late 19th and early 20th centuries, land acts and railroads affected Central Plain's settlement patterns. The Land Ordinance of 1785 quartered off 640 acre sections that were sold for $1 per acre. Various land acts followed until the Homestead Act of 1862 allowed settlers to acquire 160 acres for $1.25 per acre, which transferred the public domain into the private sector. By 1852, the Illinois and Michigan canal was a transportation route that connected the Central Plains to Lake Michigan and the Mississippi River, and the Michigan Central Railroad was the first railroad to connect Chicago to eastern states (Senning et al. 1914,

p. 14). By 1863, the Central Pacific Railroad (CPRR) started east from Sacramento using mostly Chinese immigrant labor (Carson, 2005), and in 1865, the Union Pacific Railroad (UPRR) started west from Omaha using Irish immigrants and ex-Confederate Civil War veterans. To generate revenue, the railroads recruited passengers from Eastern states and Europe, offering them land between $2 and $10 per acre (Cochrane, 1979, pp. 84-85).

During much of the late 19^{th} and early 20^{th} centuries, the Central Plains was an agricultural region where grains, beef, and dairy products were produced and shipped to eastern and European markets for household consumption. Throughout its initial development, the Central Plains was sparsely populated, and increasing immigration soon populated large tracks of lands that were transformed into productive farmlands with varying degrees of agricultural success (Atack and Bateman, 1987, pp. 186-200; Carson, 2010). Technological innovations were fundamental to the region's economic development, and the reaper, steel plow, barbed wire, and refrigeration increased agricultural productivity (Cochrane, 1979, pp. 194-195; Federico, 2013, pp. 160-161; Craig et al, 2004, pp. 328-333). Compared to elsewhere within the US, farmers on the northern Plains rapidly adopted technologies and increased the number of acres devoted to corn and became among the most productive corn and wheat producing regions (Hilliard, 1972, p. 166; Griliches, 1971, p. 208; Olmstead and Rhode, 2008, pp. 71-86). By the 1920s, new biotechnologies were in development that included fertilizers, herbicides, and genetically modified plant varieties (Atack and Bateman, 1987, pp. 186-188). Subsequently, late 19^{th} and early 20^{th} century Central Plains' economic development were related to its prominent river basins, early US explorations, and transportation revolutions, which were related to net nutrition on the Central Plains.

III. Late 19th and Early 20th Century Central Plains' BMIs, Weight, and Height Data

Data used to study Plain's net nutrition is part of a large 19th century prison data extraction project. All US prisons were contacted on multiple occasions, and available state prison records were acquired and entered into a master file. Prison records used in this study for the Central Plains are for the Colorado, Illinois, Missouri, Montana, and Nebraska prisons.[1] Between 1871 and 1944, there were 61,345 males in the Central Plains with complete age, height, weight, nativity, residence, and pre-incarceration occupations. Physical characteristics were recorded by prison enumerators at the time of incarceration, therefore, reflect pre-incarceration conditions, and are used here to evaluate changing net nutrition as development occurred. During this pre-photographic period, physical descriptions were recorded in detail as a means to identify individuals in case they escaped and were recaptured. Physical descriptions were also used to identify individuals within prisons.

Because institutions that randomly collected data were yet to develop, all historical data have various biases that reflect the purposes for which they were collected. The two most common sources for historical weight and height data are military and prison records. While plentiful, 19th century military records reflect socioeconomic conditions among the upper class that had minimum stature requirements for service (Sokoloff and Villaflor, 1982, pp. 456-458; Komlos 1987; Coclanis and Komlos, 1995, p. 93; Ellis, 2004, p. 27). However, because military recruits were rejected for short statures, it may understate military BMIs because height is inversely related to BMI, and disproportionately taller individuals remained in military records.

[1] Prison records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Maryland, Mississippi, Missouri, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania, Philadelphia, Tennessee, Texas, Utah, and Washington.

Prison records do not suffer from this truncation bias and may better reflect conditions among lower socioeconomic groups (Komlos and Carson, 2017, p. 138, footnote 5). Like military records, prison data are not random but contain valuable information in net nutrition studies, such as conditions among lower socioeconomic groups who were more vulnerable to economic change (Floud et al 2011, p. 62). There are, however, concerns with prison records. For example, if law enforcement trained recruits to target taller individuals in physical assault crimes, taller individuals may have been more likely to be incarcerated in prison records (Komlos and Carson, 2017, p. 141). Alternatively, prison records may be more likely to represent conditions among the poor and working class who turned to crime out of privation. Stature measures cumulative net nutrition throughout life, and if incarceration was related to material wealth, prison records may reflect shorter, individuals who were unable to afford legal counsel at trial (Carson, 2010).[2] Subsequently, prison records are a valuable source to examine 19th century BMIs, height, and weight records that reflect conditions on the Central Plains.

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[2]There is also a recent challenge to the established result that US statures decreased during the 19th century's second and third quarters due to sample selection, however, remains unsettled in the literature (Bodenhorn et al, 2014). Nevertheless, this revised view may itself suffer from sample-selection biases and does not account for various sources that show health and net nutrition deteriorated with urbanization and development (Zimran, 2017, p. 31; Komlos and A'Hearn, 2016). Recent criticisms to the antebellum paradox also do not account for the well-established interdisciplinary evidence that illustrates urban statures were shorter and decreased with the separation of food consumption from production (Zehetmayer, 2011; Haines, Craig, and Weiss, 2003, pp. 398-407; Davidson et al. 2002, p. 268; Steckel and Rose, 2002, p. 575; Carson, 2008, p. 368; Nicholas and Oxley, 1993, p. 734). Statures were also shorter in geographic regions with higher diseases rates (Haines, Lee, and Weiss, 2003; Coelho and McGuire, 2000, p. 239-243), and nutrition and disease are essential explanations in the antebellum paradox (Floud et al. 2011, p. 11).

During the late 19th and early 20th centuries, prison enumerators recorded complexions, which are used here to classify race. Individuals of African descent were recorded as black, light-black, dark-black, chocolate, copper, and various shades of mulatto. Individuals of European decent were recorded as fair, white, medium, and dark. These European complexions are further supported because inmates of European ancestry were also recorded with the same fair, white, medium, and dark complexions. In both the federal census and in prison records, persons of mixed African and European ancestry were referred to as 'mulatto.' However, in the results that follow, persons of mixed African and European descent are referred to as 'mixed-race.'[3] Native Americans were recorded as 'Indians,' and individuals of European and Native Mexican ancestry were recorded as 'Mexican' (Carson, 2018).[4] There were also individuals from China, Japan, and Korea on the Central Plains who are classified as Asian. Because individuals of African and European-descent are the largest part of the Central Plain's population, their biological conditions are the primary focus of this study.

In the late 19th and early 20th centuries, occupations were the primary means of classifying socio-economic status, and five occupation categories are used here to classify socioeconomic status: white-collar, skilled, farmers, unskilled workers, and persons with no listed occupation. Bankers, merchants, and ministers are classified as white-color workers. Craft workers, butchers, and tailors are classified as skilled workers. Ranchers, dairymen, and farmers are classified as farmers. Cooks and laborers are classified as unskilled workers. A final

[3] Arizona and Montana are the only two prisons that recorded both written complexion descriptions with photographs, and it is clear from the Arizona and Montana records are consistent across regions that individuals described as mulattos with written descriptions.

[4] An individual of mixed European and indigenous Mexican ancestry is classified as Mexican Mestizo (Carson, 2018).

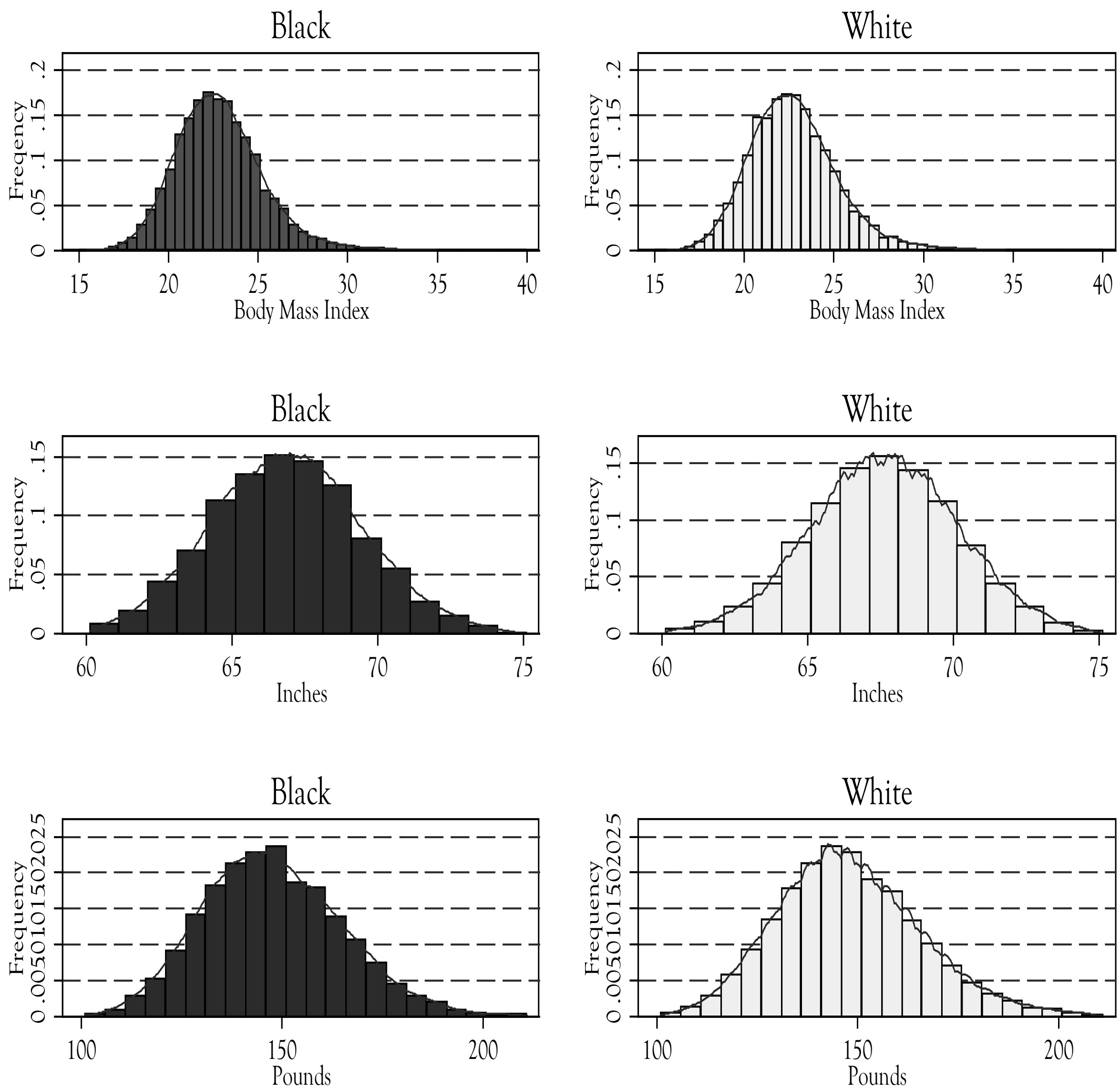
category is used for individuals who recorded no occupation or reported no discernable occupation to prison enumerators.

Table 1, Later 19th and Early 20th Century Plains Descriptive Statistics

	N	*Percent*	*BMI*	*S.D.*		*N*	*Percent*	*BMI*	*S.D.*
Ages					**Ethnic**				
Teens	4,654	7.60	21.84	2.09	Native-American	276	.45	23.42	2.59
20s	30,016	48.98	22.70	2.30	Asian	48	.08	21.82	2.57
30s	15,795	25.78	23.08	2.63	Black	8,796	14.35	23.26	2.40
40s	7,050	11.51	23.46	2.95	Mexican	421	.69	23.14	2.43
50s	2,778	4.53	23.61	3.11	Mixed-Race	2,248	3.67	22.84	2.44
60s	862	1.41	23.54	3.34	White	49,487	80.76	22.80	2.57
70s	121	.20	22.67	3.21	**Occupations**				
Nativity					White-Collar	8,162	13.32	22.83	2.92
Africa	42	.07	23.52	2.65	Skilled	14,540	23.73	22.81	2.54
Asia	101	.16	21.97	2.67	Farmer	7,292	11.90	23.10	2.57
Australia	71	.12	22.87	2.14	Unskilled	30,951	50.51	22.86	2.44
Canada	1,101	1.80	23.19	2.60	No Occupation	331	.54	22.75	2.53
Europe	5,485	8.95	23.86	2.59	**Received**				
Great Britain	1,733	2.83	23.17	2.47	1870s	124	.20	23.35	2.52
Latin America	96	.16	23.20	2.62	1880s	1,525	2.49	23.08	2.39
Mexico	823	1.34	23.07	2.35	1890s	3,845	6.27	22.97	2.50
US, Far West	3.047	4.97	22.88	2.34	1900s	19,640	32.05	22.77	2.50
US, Great Lakes	12,444	20.31	22.84	2.54	1910s	25,262	41.23	22.94	2.51
US, Middle Atlantic	4,539	7.41	22.97	2.56	1920s	6,197	10.11	23.07	2.71
US, Northeast	1,025	1.67	23.30	2.74	1930s	3,619	5.91	22.55	2.82
US, Plains	41,538	35.15	22.58	2.51	1940s	1,064	1.74	22.26	2.67
US, Southwest	7,088	11.57	22.83	2.55					
US, Southeast	2,143	3.50	22.78	2.40					
Total	61,276	100.00	22.87	2.55					

Source: Colorado State Archives, 1313 Sherman Street, Room 120, Denver, CO 80203; Illinois State Archives, Margaret Cross Norton Building, Capital Complex, Springfield, IL 62756; Missouri State Archives, 600 West Main Street, Jefferson City, MO 65102; Montana State Archives, 225 North Roberts, Helena, MT, 59620; Nebraska State Historical Society, 1500 R Street, Lincoln, Nebraska, 68501.

As they are today, prisoners were a younger segment of the population compared to the general population (Table 1;Wilson, 1975, p. 232; Hirschi and Gottfredson, 1983; Gottfredson and Hirschi, 1990, pp. 128-144; Freeman, 1999; Carson, 2009a). About half of the Plains sample was in their 20s and another 30 percent in their teens and 30s. Only 35 percent were native to the Central Plains, indicating the region was an area of high in-migration (Table 1; Senning et al. 1914, pp. 11-13). The most common internal US immigrants were from the Great Lakes, yet there were considerable shares from the Southwest and Middle Atlantic (Steckel, 1983). The most common international immigrants were from Continental Europe, followed by Britain, Canada, and Latin America, primarily Mexico. Whites were the most common ethnic group, followed by blacks and mixed-race individuals. Unskilled workers were the most common socioeconomic group, demonstrating prisoners were more likely from lower socioeconomic groups.[5] There were individuals who were received as early as the 1870s and as late as the 1940s, and individuals born between 1830 and 1920s.



[5] There is some concern regarding how prison unskilled workers compared to the general population. As expected, the percent of unskilled workers in the prison sample is greater than the percent in the general population, indicating the prison population represents conditions among the working class.

Figure 1, Late 19th and Early 20th Century BMIs, Height, and Weights

Source: See Table 1.

Note: While height is reported in centimeters for regression models, heights were reported in inches in US prisons and reported here in inches.

Because of the effects of disease and obesity, it is not clear how historical BMIs and health align with modern standards (Floud et al. 2011). Body mass, height, and weight distributions offer valuable insight into net nutrition, and 19th century black and white distributions were reasonably symmetric, indicating Central Plains' residents received neither an excess nor were they deficient in calories relative to claims from work and the physical environment (Figure 1). In contrast to modern distributions, the majority of black and white BMIs on the 19th century Central Plains were in normal categories, and workers were neither stunted nor obese (Figure 1; Fogel, 1994, p. 378; Carson, 2009b; Carson, 2012c; Flegal et al. 2010). Average black BMI was 23.26; average white BMI was 22.80. As they were elsewhere throughout the US, individuals were unlikely to be underweight. Only 1.19 percent of blacks and 2.50 percent of whites were underweight. Most individuals were in normal weight categories, and 77.44 and 79.84 percent of blacks and whites were in the normal category. Only 21.27 percent of blacks, and 18.18 percent of whites were overweight or obese. However, while

Year	*US Population*	*Prisoners*
1850s		32.9
1860s		58.2
1870s	31.9	52.6
1880s	30.4	47.5
1890s		52.0
1900s	33.1	52.3
1910s	29.5	46.9
1920s	23.6	37.8

Source: US general population estimates are from Rosenbloom, 2002, p. 88.

blacks had greater average BMIs and were more likely to be overweight and obese, it does not indicate they were in better physical condition because they were shorter than whites, and BMIs are inversely related to height (Carson, 2009b; Carson, 2012b; Komlos and Carson, 2017). Individuals with darker complexions also have more protein in muscle tissue, and for the same tissue volume, muscle is heavier than fat (Barondess, 1997; Wagner and Heyward; Aloi et al. 1997).

Central Plains' height and weight distributions are also insightful (Figure 1). Average black and white heights were 169.81 and 171.81 centimeters, respectfully. Average black weight was 148.01 pounds, while average white weight was 148.46 pounds, indicating that blacks were short and heavy, and whites had about the same weights but were taller. In sum, late 19th and early 20th century black and white males on the Central Plains were in healthy, normal ranges, and health on the Central Plains that was poor by modern standards was not likely related to BMIs (Floud et al. 2011).

IV. The Demographic, Socioeconomic, Residential, and Ethnic Effects on the Central Plains Net Nutrition

The timing and extent of BMI variation reflects how biological conditions vary by ethnic status, demographics, socioeconomic conditions, and residence. BMI classifications are now evaluated with multinomial regression models, and coefficients are reported as odds ratios of being in the underweight, overweight, and obese relative to the normal BMI category. Least squares height and weight models are used to evaluate cumulative and current net nutrition.

Multinomial BMI Model

$$\log\left(\frac{p_j}{p_{Normal}}\right) = \theta_0 + \theta_c Centimeters_i + \sum_{r=1}^{5}\theta_r Ethnicity_i + \sum_{a=1}^{13}\theta_a Age_i + \sum_{t=1}^{7}\theta_t Observation\,Period_i$$

$$+ \sum_{n=1}^{14}\theta_n Nativity_i + \sum_{l=1}^{4}\theta_l \,\mathrm{Re}\,sidence_i + \sum_{j=1}^{6}\theta_j Occupation_i + \varepsilon_i \qquad (1)$$

Least Squares Height Model

$$Centimeters_i = \theta_0 + \sum_{r=1}^{5}\theta_r Ethnicity_i + \sum_{a=1}^{13}\theta_a Age_i + \sum_{t=1}^{7}\theta_t Birth\,Period_i + \sum_{n=1}^{14}\theta_n Nativity_i$$

$$+ \sum_{l=1}^{4}\theta_l \,\mathrm{Re}\,sidence_i + \sum_{j=1}^{6}\theta_j Occupation_i + \varepsilon_i \quad (2)$$

Least Squares Weight Model

$$Weight_i = \theta_0 + \theta_c Centimeters_i + \sum_{r=1}^{5}\theta_r Ethnicity_i + \sum_{a=1}^{13}\theta_a Age_i + \sum_{t=1}^{7}\theta_t Observation\,Period_i$$

$$+ \sum_{n=1}^{14}\theta_n Nativity_i + \sum_{l=1}^{4}\theta_l \,\mathrm{Re}\,sidence_i + \sum_{j=1}^{6}\theta_j Occupation_i + \varepsilon_i \qquad (3)$$

Stature in centimeters is included to test the inverse relationship between BMI and cumulative net nutrition (Carson, 2009b; Carson, 2012c). Complexion dummy variables are included to assess how BMIs varied by ethnic status. Youth age dummy variables are included for ages 15 through 22, and adult age decade dummy variables are included for ages 30 through 70. Observation decade variables are included to assess how BMIs and weight varied between 1870 and 1940. Birth decade dummy variables are included in the height regression to illustrate how height varied for birth between the 1830s and 1920s. US nativity dummy variables are included for nativity from the Northeast, Middle Atlantic, Great Lakes, Southeast, Southwest, and Far West. International nativity variables are included for birth in Asia, Great Britain, Europe, and Latin America. Plains residence dummy variables are included to measure regional access to nutrition. Occupation dummy variables are included to account for socioeconomic status and physical activity.

Table 2, Late 19th and Early 20th Century Multinomial BMI by Demographics, Residence, and Socioeconomic Status

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Total	Under	Over	Obese	Black US	White US
Intercept	30.34***	1.62^{-5}***	26.29***	439.31*	32.01***	29.84***
Height						
Centimeters	-.046***	1.04***	.970***	.935***	-.049***	-.436***
Ethnicity						
White	Reference	Reference	Reference	Reference		
Black	.937***	.371***	1.94***	1.46***	Reference	
Mixed-Race	.651***	.610***	1.58***	1.42*	-.351***	
Native-American	.585**	1.09	2.31***	1.57		
Asian	-.341	.945	.334**	5.77**		
Mexican	-.021	1.19	1.06	1.16		
Ages						
15	-2.43***	11.06***	.272***	5.31^{-8}***	-2.88***	-2.19***
16	-1.34***	5.21***	.383***	2.96^{-7}***	-1.66***	-1.13***
17	-1.32***	2.96***	.277***	3.69^{-7}***	-1.55***	-1.15***
18	-.991***	2.13***	.373***	.189***	-1.11***	-.970***
19	-.670***	1.79***	.484***	.142***	-.718***	-.636***
20	-.356***	1.12***	.634***	.615***	-.362***	-.352***
21	-.248***	1.22***	.736***	.815***	-.157***	-.259***
22	-.149***	1.14***	.791***	.617***	-.145***	-.129***
23-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	.287***	1.06***	1.27***	2.68***	.275***	.285***
40s	.626***	1.18***	1.57***	5.24***	.385***	.678***
50s	.792***	1.18***	1.81***	6.95***	.727***	.821***
60s	.715***	1.92***	1.89***	6.28***	.363***	.684***
70s	-.037***	4.68***	1.56***	5.71***	.018	-.090***
Observation Period						
1870s	-.146	1.67	.547***	2.87***	1.32***	-.190
1880s	.605***	.632**	1.61***	1.01	.855***	.630***
1890s	-.010	.811	.964	1.28***	.011	-.023
1900s	-.157***	1.14	.899***	.919	-.164***	-.154***
1910s	Reference	Reference	Reference	Reference	Reference	Reference
1920s	.203***	.976	1.11***	1.49***	.171	.235***
1930s	.160*	.976	1.05	1.66***	-.150	.191*
1940s	-.033	1.15	1.10	1.35	-.129	-.085
Nativity						
Northeast	.164**	.867	1.04	1.25	.728	.160***
Middle-Atlantic	-.080**	.988	.910***	.654**	.072	-.059

Great Lakes	-.045	.934	.936**	1.03	-.144	-.006
Plains	Reference	Reference	Reference	Reference	Reference	Reference
Southeast	-.245***	1.31***	.793***	.927	-.173***	-.248***
Southwest	-.266***	.910	.772***	.604**	-.160***	-.250***
Far West	-.243***	.974	.839***	.604**	-.343**	-.213***
Africa	.500	1.29	1.33	2.95***		
Asia	-.183***	10.81***	.333***	.065***		
Australia	-.344	3.20^{-7}***	.770	2.35^{-7}***		
British	-.103***	.821	.975	.662***		
Canada	-.064	1.30***	.967	.943		
Europe	.678***	.489***	1.62***	1.10		
Latin America	-.256	1.69	.852	.552		
Mexico	-.258***	.933	.839	.307***		
Residence						
Colorado	1.15***	.268***	2.20***	2.17***	1.07***	1.15***
Illinois	.654***	.602***	1.63***	2.04***	.404***	.679***
Missouri	Reference	Reference	Reference	Reference	Reference	Reference
Montana	1.40***	.181***	2.60***	2.15***	1.01***	1.44***
Nebraska	.043	.965	1.10***	1.27***	-.246***	.136***
Occupations						
White-Collar	-.354***	2.19***	.845**	1.62***	-.463***	-.346***
Skilled	-.377***	1.51***	.768***	.837	-.369***	-.381***
Farmers	Reference	Reference	Reference	Reference	Reference	Reference
Unskilled	-.305***	1.40***	.814***	.859	-.383***	-.329***
No Occupations	-.573***	3.48***	.758*	.455	.005	-.517**
N	61,276	61,276	61,276	61,276	10,793	40,646
R^2	.1067	.0616	.0616	.0616	.0798	.0893

Source: See Table 1.

Note: *** Significant at α=.01; **Significant at α=.05; * Significant at α=.10. Robust standard errors clustered on age.

Table 3, Late 19th and Early 20th Century Height and Weight by Ethnic Status

	Blacks			White		
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Cent	Pounds	Kilo	Cent	Pounds	Kilo
Intercept	170.71***	-94.60***	-42.91***	172.58***	-103.34***	-46.88***
Inch		3.66***			3.68***	
Cent			.654***			.657***
Ethnicity						
White						
Black	Ref	Ref	Ref			
Mulatto	.914***	-2.31***	-1.05***			
Ages						
15	-9.69***	-15.23***	-6.91***	-7.04***	-13.49***	-6.12***
16	-4.47***	-10.10***	-4.58***	-3.79***	-7.08***	-3.21***
17	-3.06***	-9.59***	-4.35***	-2.75***	-7.18***	-3.26***
18	-1.99***	-6.95***	-3.15***	-1.40***	-6.28***	-2.85***
19	-1.35***	-4.95***	-2.04***	-1.23***	-4.11***	-1.86***
20	-1.04***	-2.29***	-1.04***	-.416***	-2.35***	-1.07***
21	-.120**	-.976***	-.443***	-.145***	-1.73***	-.785***
22	-.535***	-.907***	-.411***	-.368***	-.900***	-.408***
23-29	Ref	Ref	Ref	Ref	Ref	Ref
30s	.392***	1.76***	.799***	.350***	1.90***	.862***
40s	-.226**	2.52***	1.14***	.165**	4.48***	2.03***
50s	-1.06***	4.70***	2.13***	-.422***	5.38***	2.44***
60s	-1.38***	2.03***	.920***	-1.43***	4.46***	2.02***
70s	.884**	.607**	.275**	-1.12***	-.615***	-.279***
Birth Period						
1830s	-2.02			-.277		
1840s	-.097			-.174		
1850s	-.259			-.136		
1860s	.359			-.023		
1870s	.199			-.025		
1880s	Ref			Ref		
1890s	.136			.381***		
1900s	1.25***			1.18***		
1910s	3.05***			2.94***		
1920s	4.49***			4.87***		
Observation Period						
1870s		8.88***	4.03***		-1.33	-.605
1880s		5.47***	2.48***		4.16***	1.89***
1890s		.105	.048		-.168	-.076
1900s		-.959***	-.435***		-.972***	-.441***
1910s		Ref	Ref		Ref	Ref
1920s		1.02	.460		1.49***	.677***
1930s		1.14	-.515		1.18	.534

1940s		-1.00	-.454		-.728	-.330
Nativity						
Northeast	.942	4.38	1.98	-2.04***	.948***	.430***
Middle Atlantic	-.604	.342	.155	-1.65***	-.428*	-.194*
Great Lakes	-.142	-.886	-.402	-.579***	-.014	-..006
Plains	Ref	Ref	Ref	Ref	Ref	Ref
Southeast	.823***	-1.08***	-.492***	.212*	-1.57***	-.714***
Southwest	1.20***	-.956***	-.434***	-.040	-1.58***	-.717***
Far West	.324	-2.18**	-.987**	-.328*	-1.42***	-.644***
Residence						
Colorado	.680**	6.79***	3.08***	-.304***	7.45***	3.38***
Illinois	.428***	2.57***	1.17***	-.018	4.40***	1.99***
Missouri	Ref	Ref	Ref	Ref	Ref	Ref
Montana	2.94***	6.37***	2.89***	2.98***	9.51***	4.31***
Nebraska	1.25***	-1.60***	-.726***	.805***	.854***	.387***
Occupations						
White-Collar	-1.33***	-2.32***	-1.33***	-.752***	-2.21***	-1.00***
Skilled	-1.54***	-2.32***	-1.05***	-.829***	-2.52***	-1.14***
Farmer	Ref	Ref	Ref	Ref	Ref	Ref
Unskilled	-1.61***	-2.42***	-1.10***	-.783***	-2.14***	-.970***
No Occupation	-.536	-.089	-.041	-2.08***	-3.32**	-1.51**
N	10,793	10,793	10,793	40,646	40,646	40,646
R^2	.0437	.3538	.3538	.0583	.3203	.3203

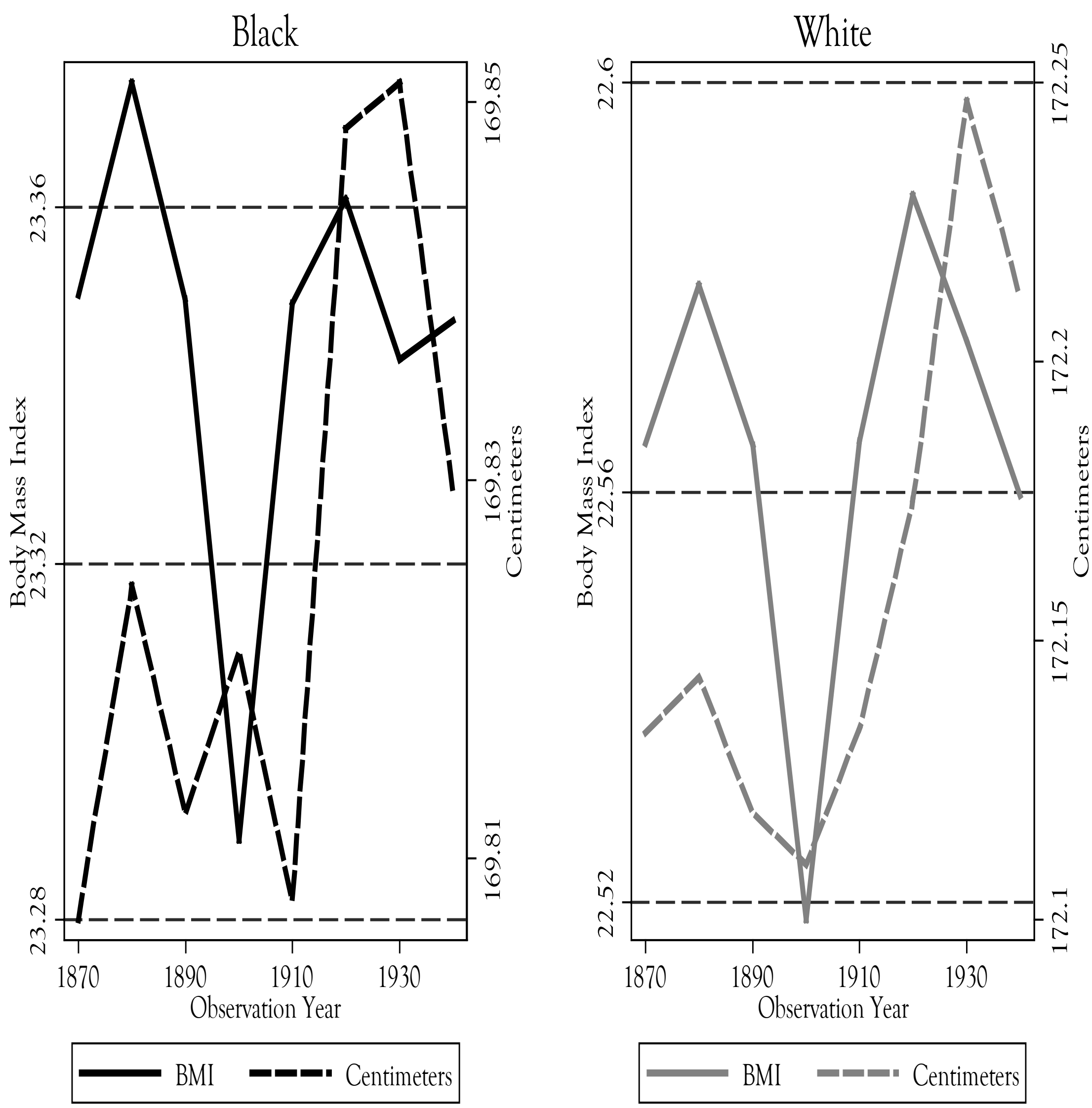
Source: See Table 1.

Notes: *** Significant at α=.01; **Significant at α=.05; * Significant at α=.10. Robust standard errors clustered on age.

Three paths of inquiry are considered when evaluating net nutrition on the Central Plains. First, in 1893, Frederick Jackson Turner proposed that the Central Plains served as a ‘safety valve,’ a place where migrants escaped the rigid economic and social strictures in Eastern states and Europe that prevented their upward economic mobility (Turner, 1893; Senning et al. 1914, p. 13). However, Turner’s hypothesis has faced recent criticism from Libecap and Hansen (2002, p. 88) and Hansen and Libecap (2004, p. 127) who suggest that settlers on the Plains were slow to respond to changes in weather patterns and information asymmetries. If settlers on the Central

Plains were slow to respond to weather patterns and information asymmetries, BMIs, height, and weight should have decreased with settlement (Tables 2 and Figure 2). However, white BMIs, height, and weight increased during the late 19th and early 20th centuries, indicating that net nutrition on the Central Plains improved with economic and agricultural development. Black BMIs decreased mildly; however, the decrease was largely due to taller statures and improved cumulative net nutrition, indicating that black cumulative net nutrition also improved with settlement. Subsequently, recent criticisms to Turner's 'safety-valve' hypothesis are not well supported by net nutrition measures, and economic conditions and net nutrition improved on the Central Plains during the earliest stages of economic development.

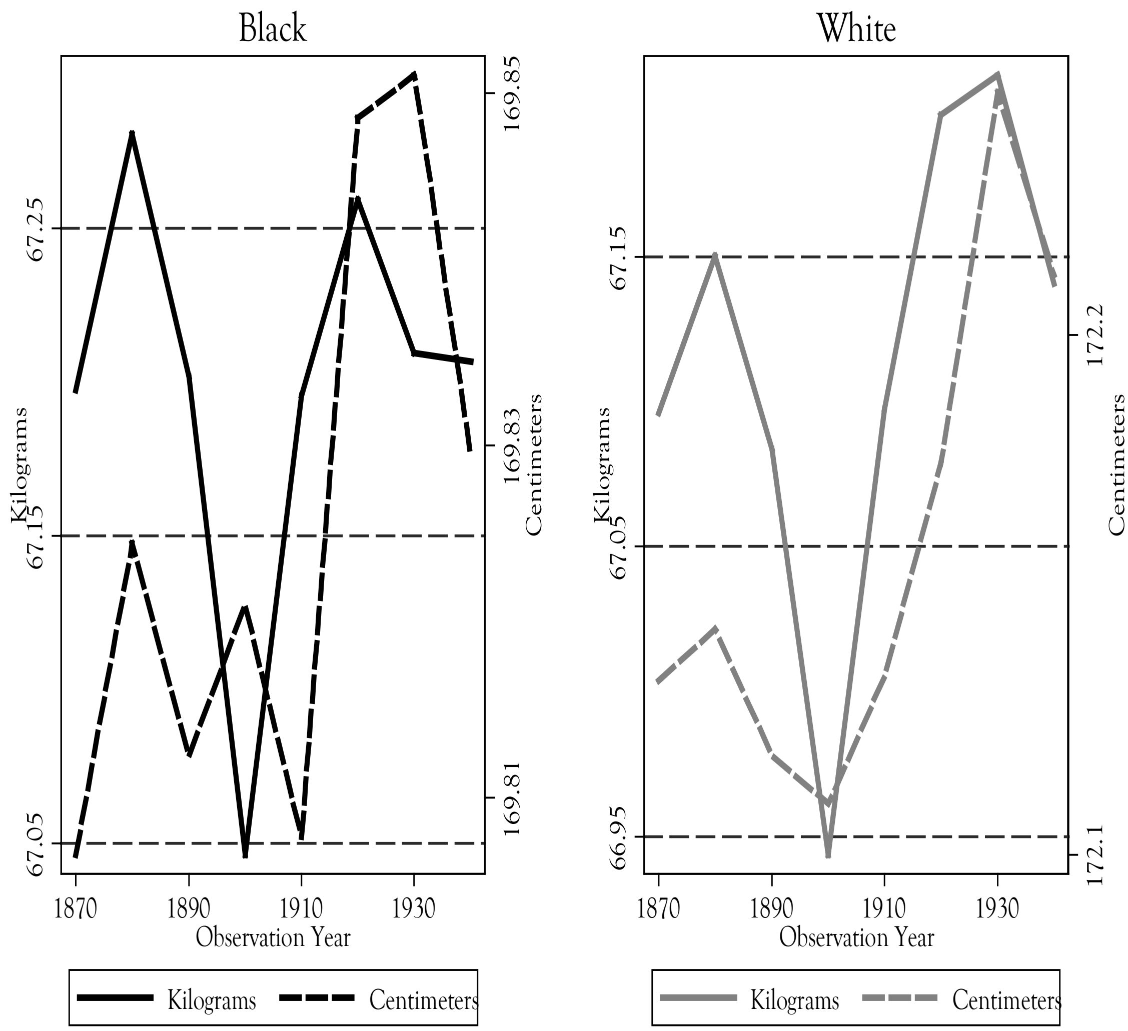
Figure 2, Central Plains Body Mass and Height, 1870-1940



Source: See Tables 1 and 2.

Note: Observation Year time coefficient weighted by proportion for each time period.

Figure 3, Central Plains Weight and Height by Ethnic Status,1870-1940



Source: See Tables 1 and 2.

Note: Observation Year time coefficient weighted by proportion for each time period.

Second, Central Plain's net nutrition was related to socioeconomic status, and the majority of late 19th century workers were in agriculture, if only for transportation and to maintain the household (Dimitri et al., 2005; Rosenbloom, 2002, p. 88). Agricultural occupations are an additional measure to test Turner's hypothesis because if recent challenges are correct, Central Plain's agricultural workers made systematic errors and were slow to adjust farm sizes and crop mixes in response to changing environmental conditions. Great Plain's farmers had between .300 and .370 greater BMI values compared to workers in other occupations. To compare how Central Plain's farmer BMIs compared to farmers elsewhere with the US, Carson (2009b) and Carson (2012c) show that agricultural workers at the national-level and in Texas had between .200 and .205 unit BMI units higher than workers with no occupation, indicating that rather than a net nutritional disadvantage, Central Plains' farmer BMI values were greater than other workers in the US and other workers within the Great Plains.

However, higher BMIs may result from workers with greater BMIs selecting into agricultural occupations or agricultural workers receiving better net nutrition due of proximity to nutrition (Margo and Steckel, 1992, p. 518; Steckel and Haurin, 1994, p. 122). Propensity score matching is a statistical technique that accounts for selection and separates average BMIs, height, and weight into different cohorts based on occupations after accounting for characteristics. A dilemma in identifying causal effects is that an observation unit can only be observed with or without treatment, not both. Propensity score matching is used to address this counterfactual problem by matching observations with similar propensity scores and separating them whether or not they received treatment (Dehejia and Wahba, 2002, p. 152). Equation 4 is the treatment on the treated effect for nutrition after becoming a farmer.

$$\Delta^{T} = \frac{1}{|N|}\sum_{i \in N}\left[y_i - \sum_{j}\frac{1}{|J_i|} y_j \right] \qquad (4)$$

where Δ^T is the value of treatment. N is the treatment group. $|N|$ is the number of units in the treated group. J_i is the comparison group matched to the i[th] group in N, and $|J_i|$ is the number of observations in the J_i comparison group (Dehejia and Wahba, 2002, p. 153).[6]

Propensity score matching assumes dependent variable differences are due to treatment and not characteristic differences. Table 4 illustrates that farmers were on average taller than non-farmers; however, the occupation panels are, otherwise, reasonably similar.

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[6] Propensity score matching is not without criticism. One drawback with matching is that there is little agreed upon guidance for the independent variables (Heckman. et al. 1998). There are diverse model specifications, but no formal means to select alternative model specification (DiNardo and Lee, 2011, p. 253). There is also a compelling argument that over fitting on the treatment variable increases the bias associated with matching techniques. Although propensity score matching is an effort to model causal effects, for the results reported here to be interpreted as causal, there should be no unobserved variables that influence biological measures and the probability of being a farmer.

Table 4, Sample Means and Standard Errors of Covariates

	Farmers		**Non-Farmers**	
	Mean	Standard Error	Mean	Standard Error
Height				
Centimeters	172.95	6.69	171.23	6.68
Ages				
15	2.74^{-4}	.017	5.56^{-4}	.024
16	2.47^{-3}	.050	.002	.045
17	8.78^{-3}	.093	.010	.098
18	.028	.164	.027	.163
19	.033	.178	.037	.188
20	.041	.197	.038	.192
21	.050	.217	.050	.218
22	.058	.233	.063	.242
23-29				
30s	.249	.432	.259	.438
40s	.140	.347	.112	.315
50s	.062	.242	.043	.203
60s	.165	.127	.014	.116
70s	.003	.056	.002	.043
Observation Period				
1870s	.002	.042	.002	.045
1880s	.045	.208	.022	.147
1890s	.052	.222	.064	.245
1900s	.200	.400	.337	.473
1910s				
1920s	.151	.358	.095	.293
Nativity				
Northeast	.007	.083	.018	.133
Middle Atlantic	.033	.179	.080	.271
Great Lakes	.180	.385	.206	.405
Plains				
Southeast	.092	.289	.119	.324
Southwest	.039	.195	.034	.182
Far West	.064	.245	.048	.213
Africa	1.37^{-4}	.012	7.80^{-4}	.028
Asia	4.11^{-4}	.020	.002	.043
Australia	2.74^{-4}	.017	.013	.036
Britain	.014	.018	.030	.171
Canada	.015	.120	.018	.134
Europe	.068	.252	.092	.290

Latin America	4.11^{-4}	.020	.002	.042
Mexico	.009	.093	.014	.118
Residence				
Colorado	.135	.341	.107	.309
Illinois	.088	.283	.211	.408
Montana	.222	.416	.172	.377
Nebraska	.310	.462	.153	.360

Source: See Table 1.

Table 5, Late 19th and Early 20th Century Propensity Scores on Occupations

	BMI ATE	*BMI ATET*		*Weight ATE*	*Weight ATET*
BMI			**Weight**		
White-Collar	-.088**	-.025	White-Collar	-.196	-.158
	(.042)	(.040)		(.135)	(.126)
Skilled	-.121***	-.089***	Skilled	-.362***	-.246***
	(.028)	(.030)		(.090)	(.095)
Farmer	.430***	.278***	Farmer	.971***	.129
	(.075)	(.040)		(.149)	(.129)
Unskilled	-.017	-.030	Unskilled	-.082	-.094
	(.025)	(.031)		(.077)	(.094)
No Occupation	-.434***	-.196	No Occupation	-.317	-1.49***
	(.150)	(.152)		(.631)	(.471)
Height (cms)	Height ATE	Height ATET			
White-Collar	-.019	.058			
	(.095)	(.078)			
Skilled	-.160**	-.158**			
	(.071)	(.064)			
Farmer	.789***	.812***			
	(.133)	(.087)			
Unskilled	-.283***	-.262***			
	(.058)	(.068)			
No Occupation	.315	-.982***			
	(.573)	(.373)			

Source: See Table 1.

Notes: *** significant at α=.01; ** significant at α=.05; * significant at α=.10. Value in parentheses are standard error. Height measured in centimeters. Weight measured in kilograms.

If agricultural conditions deteriorated with economic development, farmer net nutrition after accounting for selection should have been lower than other agricultural workers throughout the US. To isolate the effect of occupation selection on BMI, the average treatment effect on BMI outcomes was .278 units greater than workers in other occupations (Tables 2, 4, and Table 5; Carson, 2009b; Carson, 2012b). After accounting for occupational selection, Plain's farmer BMI unit differences were also similar to regression coefficients. Extending propensity score matching to weight and height biological measures show that after accounting for selection, Central Plains farmer heights were .789 centimeters taller than workers in other occupations and had nearly one pound greater weight (Tables 3 and 5), indicating that after accounting for selection, farmers had greater BMIs, were taller, and had greater weights than workers in other occupations. Moreover, farmers on the Great Plains had higher BMIs than workers in other occupations, taller statures, and greater weights, indicating that much of the farmer BMI advantage accrued after occupational selection (Table 2 and Table 3; Carson, 2009b, p. 125; Carson, 2012c, p. 383). Carson (2009a, p. 155) shows US national farmer statures were about one centimeter taller than workers in other occupations, and Carson (2015c, p. 959) shows that national farmer weights were about two pounds heavier than workers in other occupations. Alternatively, white-collar and skilled workers had lower BMIs than agricultural workers and were more likely to be underweight (Tables 2 and 4).[7] In sum, if net nutrition on the Central Plains decreased with settlement, farmers—the occupation most vulnerable to agricultural variation—should have experienced net nutritional privation compared to workers in other occupations. However, Central Plains' farmer BMIs, height, and weight were greater than workers in other occupations and was comparable to or exceeded farmers in other regions across the US.

Third, Steckel (1979, p. 374) demonstrates that whites were taller than African-Americans, and Bodenhorn (2002, pp. 23, 30, and 43) suggests much of the stature difference

[7] From the national level adult black white-collar worker BMIs were slightly below and skilled worker BMIs slightly above, while national adult white white-collar and skilled worker BMIs were both .246 and .133 BMI units higher than workers with no listed occupations; however, national adult black and white white-collar and skilled workers BMI did not exceed national agricultural worker BMIs.

was due to social preferences that disproportionately favored individuals with fairer complexions. If social preferences were a primary explanation for better net nutrition, individuals on the Central Plains with fairer complexions should have had higher BMIs, taller statures, and heavier weights than individuals with darker complexions.[8] However, African-Americans had greater BMIs and heavier weights than whites (Table 3), indicating that social preferences favoring individuals with fairer complexions is independently an unlikely explanation for net nutritional variation (Eveleth et al, 1966; Tanner, 1977; Carson, 2008, Carson, 2015b; Carson, 2017). Moreover, this pattern where late 19th and early 20th century US blacks had greater BMIs and heavier weights was common both in areas where bound and free labor were the primary labor force, indicating the type of labor system does not account for BMI differences. Multiple explanations account for why 19th century whites were taller than blacks. While blacks and whites may have the ability to reach comparable average statures when brought to maturity under ideal biological conditions, optimal environments may have differed between the two groups (Carson, 2008; Carson, 2009a). For BMI and weight, blacks have greater bone-mineral density and higher percent muscle than fat, which are associated with higher BMIs and greater weights for individuals with fairer complexions (Schutte et al. 1984; Wagner and Hayward, 1997; Aloi et al, 1997; Burkhauser and Cawley, 2008).

Other patterns are consistent with expectations. Net nutrition varied with nativity, and whites from the northeastern US had the highest BMIs, and individuals from Missouri the lowest (Table 2 and 3). Much of these BMI differences were due to stature. BMIs are inversely related to height, and individuals native to the South were taller, while individuals in the Northeast were

[8] Carson (2008) and Carson (2009a) illustrates that individuals with fairer complexions may have been taller because of greater vitamin D.

shorter. Reflecting poor European net nutrition and better access to net nutrition after arrival, Continental Europeans had greater BMIs than other nativities because Europeans were shorter and had less space to distribute weight but received improved net nutrition after their US arrival (Tables 2; Koepke and Baten, 2005; Koepke and Baten, 2016; Dirks, 2016, 99-130). Residence within the Central Plains is also noteworthy. Cuff (2005, pp. 217-218) and Zehetmeyer (2011) show that statures were inversely related to urbanization and economic development. Prince and Steckel (2003, p. 369) find an inverted U-shaped height by latitude gradient for Native-Americans, US-born whites, and European immigrants and attribute these spatial patterns to differences in diets, work effort, and disease. For the majority of Central Plain's populations, communities remained rural and population densities low. Besides Chicago and Saint Louis, the late 19th and early 20th Century Central Plains were rural and only in certain enclaves did industrialization and urbanization takes root (Chernow, 2017, p. 31). In sum, despite recent challenges, the Plains net nutrition increased with economic development, and the biological explanation for Turner's hypothesis remains a robust and reasonable explanation for net nutritional conditions on the Central Plains.

V. Decomposing Black and White Biological Differences on the Central Plains

Evaluating BMI, height, and weight regression models indicates how net nutrition varied by ethnic status and characteristics. They do not, however, illustrate how net nutrition varied by complexion across BMI, height, and weight associated with returns to characteristics versus average characteristics. A Blinder-Oaxaca decomposition is a statistical technique that separates response variable differences into returns to characteristics and average characteristics (Blinder, 1973; Oaxaca, 1973). To illustrate how black and white net nutrition varied by structure and composition, let γ_h and γ_l represent BMI, height, and weight values by ethnic group. Black BMI and weight are the base category for BMI and weight, and white stature is the height base category. θ_{0h} and θ_{0l} are the non-identifiable net nutrition sources in the intercept. θ_{1h} and θ_{1l} are high and low response variable returns to characteristics. $\overline{X}_h$ and $\overline{X}_l$ are high and low average characteristic matrices. The coefficient vectors and characteristic matrices are expressed in equations 4 and 5.

$$\text{High response variable:}\quad \gamma_h = \theta_{0h} + \theta_{ih}\overline{X}_{1h} \qquad (4)$$

$$\text{Low response variable:}\quad \gamma_l = \theta_{0l} + \theta_{il}\overline{X}_{1l} \qquad (5)$$

High and low response variable gaps are the difference between high and low response variables.

$$\Delta\gamma = \gamma_h - \gamma_l = \theta_{0h} + \theta_{1h}\overline{X}_h - \theta_{0l} - \theta_{1l}\overline{X}_l \qquad (6)$$

The counterfactual is obtained by adding and subtracting $\theta_{ih}\overline{X}_l$ to the right-hand side of equation 6 and collecting like terms is

$$\Delta\gamma = \gamma_h - \gamma_l = (\theta_{0h} - \theta_{0l}) + (\theta_{1h} - \theta_{1l})\overline{X}_h + \theta_{1l}(\overline{X}_h - \overline{X}_l) \qquad (7)$$

Equation 7's first right hand side element, $(\theta_{0h} - \theta_{0l})$, is the black and white BMI, heights, and weight autonomous differences associated with non-identifiable characteristics in the intercept, such as diets and physical activity. The second right hand side element, $(\theta_{1h} - \theta_{1l})\overline{X}_h$, is the structural difference associated with returns to characteristics, such as age and occupations. The third right hand side element, $\theta_{1l}\left(\overline{X}_h - \overline{X}_l\right)$, is the black-white composition differences associated with average characteristics.[9]

[9] There is some dispute over the value of decomposing dependent variable differences into returns to characteristics and average characteristics because returns to characteristics vary with respect to the omitted reference category (Oaxaca and Ransom, 1999). These is little dispute explaining the dependent variable gap with composition differences, $\theta_{1l}\left(\overline{X}_h - \overline{X}_l\right)$. However, because the intercept is sensitive to the omitted category, identification is less clear for $\left(\theta_{0h} - \theta_{0l}\right) + \left(\theta_{1h} - \theta_{1l}\right)\overline{X}_h$, and there is some degree of arbitrariness in selection of the omitted categorical variable (Yun, 2008; Fortin, Lemieux, and Firpo, 2011, pp. 40 and 45).

Table 6, Late 19th and Early 20th Century Central Plain's BMI, Height, and Weight Decompositions

Panel A				
BMI	$(\beta_b - \beta_w)X_b$	$(X_b - X_w)\beta_w$	$(\beta_b - \beta_w)X_w$	$(X_b - X_w)\beta_b$
Levels				
Sum	1.14	-.379	.978	-.22
Total		.758		.758
Proportions				
Intercept	2.89		2.89	
Height	-1.12	.139	-1.14	.154
Ages	-.061	-.132	-.067	-.126
Observation Period	-.012	-.025	-.036	-.002
Nativity	.029	-.070	-.013	-.028
Residence	-.142	-.377	-.284	-.235
Occupations	-.082	-.034	-.062	-.055
Sum	1.50	-.500	1.29	-.291
Total		1		1
Panel B	$(\beta_w - \beta_b)X_w$	$(X_w - X_b)\beta_b$	$(\beta_w - \beta_b)X_b$	$(X_w - X_b)\beta_w$
Height				
Levels				
Sum	1.67	.666	1.97	.360
Total		2.33		2.33
Proportions				
Intercept	.698		.698	
Ages	.057	.036	.056	.036
Birth Period	-.049	.042	-.023	.016
Nativity	-.192	-.112	-.159	-.145
Residence	-.081	-.247	-.051	.217
Occupations	.285	.069	.323	.031
Sum	.718	.282	.845	.155
Total		1		1
Panel C	$(\beta_b - \beta_w)X_b$	$(X_b - X_w)\beta_w$	$(\beta_b - \beta_w)X_w$	$(X_b - X_w)\beta_b$
Weight				
Levels				
Sum	2.98	-3.19	2.54	-2.74
Total		-.208		-.208
Proportions				
Intercept	-19.46		-19.46	
Height	2.45	8.48	2.85	8.44
Ages	.615	1.42	.723	1.31
Observation Period	.084	.253	.361	-.023

Nativity	-.312	.725	.139	.271
Residence	1.54	4.08	3.02	2.61
Occupations	.763	.371	.559	.575
Sum	-14.34	15.34	-12.19	13.19
Total		1		1

Source: See Tables 1 and 2.

Using BMI, height, and weight coefficients from Tables 2 and 3, Table 6 presents black and white Central Plains' net nutrition decompositions. Panel A presents the BMI decomposition, and African-American BMIs were nearly one unit greater than whites. The large positive intercept illustrates that late 19th and early 20th century black BMIs were greater than whites independent of returns to and average characteristics. The black-white BMI differential varied by characteristics, and the greatest proportion of the white BMI return advantage was stature, indicating white returns to cumulative net nutrition were greater than blacks. Whites also had greater structural BMI returns associated with age, observation period, residence, and socioeconomic status. Returns to average characteristics also favored whites, which offset the autonomous biological effect, in part, but not completely.

Panel B shows the Central Plains height decomposition, and height returns to characteristics and average characteristics explain much of the white-black stature gap. Like the black BMI advantage in the intercept, whites had a large, significant stature advantage relative to blacks (Carson, 2008; Carson, 2009a). Whites were also taller than blacks associated with returns to age and socioeconomic status; black structural stature returns were greater for birth period, nativity, and residence. Black and white stature differences on the Central Plains were primarily due to returns rather than average characteristics. Panel C illustrates the black-white weight difference. The negative autonomous intercept indicates that whites on the Central Plains had greater weights than blacks independent of observable characteristics, but the source of weight associated characteristics favored blacks. Blacks had greater weight returns associated with height, age, observation period, residence, and occupations. Whites had greater weight returns associated with nativity. Subsequently, white autonomous weights on the Central Plains were greater than blacks; however, blacks had greater returns with characteristics and average characteristics that off-set the white weight returns advantage.

VI. Conclusion

There is a lively debate regarding the role that the Central Plains and western frontier had in late 19th and early 20th century US economic development. Long seen as an economic 'safety valve, Turner's hypothesis has come under recent scrutiny and a new explanation is proposed where the West was not as prosperous as previously believed because settlers lacked human capital and did not accurately predict weather patterns (Libecap and Hansen, 2002, pp. 88 and 92). If settlers on the Central Plains made systematic errors, lacked human capital, and failed to predict climatic changes, net nutrition should have decreased with western settlement, and agricultural workers' net nutrition should have been lower than workers elsewhere within the US and in other occupations. However, Central Plains net nutrition increased with westward settlement, and agricultural workers consistently had better net nutrition than workers in other occupations, and compared favorably to workers throughout the United States. The widely observed pattern that individuals with darker complexions were shorter because of social preferences is also not well supported on the Central Plains. If whites received greater net nutrition because of social preferences, whites should have had greater BMIs and weights than blacks. However, African-Americans had greater BMIs and weight than whites in this economic and geographic region where bound-labor was not the primary labor source. The upshot is that the late 19th and early 20th century Central Plains was a thriving agricultural economy, where biological measurements were in healthy ranges, which reflected economic growth and labor market development, and African-Americans did relatively well in this developing economic region where bound-labor was not the primary labor force.

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