The Journal of Socio-Economics 40 (2011) 199–207

Contents lists available at ScienceDirect

The Journal of Socio-Economics

journal homepage: www.elsevier.com/locate/soceco

Was the 19th century stature–insolation relationship similar across independent samples? Evidence from soldiers and prisoners

Scott Alan Carson *,[1]

University of Texas, Permian Basin, 4901 East University, Odessa, TX 79762, United States

ARTICLE INFO

Article history:
Received 23 May 2010
Received in revised form 4 November 2010
Accepted 16 December 2010

Keywords:
Stature
Insolation
Vitamin D

JEL classification:
I31
J15
N31

ABSTRACT

Nineteenth century white US statures varied with nutrition, disease exposure, and the physical environment. An additional explanation for stature growth is vitamin D production. However, studies that link stature to insolation and vitamin D production rely on only one comprehensive data set. To test the relationship between insolation and stature further, this study broadens the sample to include both 19th century white Civil War recruits and prisoners, and illustrates that the relationship between stature and insolation was remarkably similar between white soldiers and prisoners, adding to the evidence that there is a positive relationship between stature and insolation.

1. Introduction

The use of height data to measure living standards is now a well-established method in economics (Fogel, 1994, p. 138; Steckel, 1995, 2009; Deaton, 2008; Case and Paxson, 2008). A population's average stature reflects the cumulative interaction between nutrition, disease exposure, work, and the physical environment (Steckel, 1979, pp. 365–367; Tanner, 1962, pp. 1–27). By considering average versus individual stature, genetic differences are mitigated, leaving only economic and physical environment's relationship with stature. When diets, health, and physical environments improve, average stature increases and decreases when diets become less nutritious, disease environments deteriorate, or the physical environment places more stress on the body. Therefore, when traditional measures are unavailable, stature provides considerable insights into understanding economic processes.

Numerous studies consider 19th century US white stature variation, and a few patterns are now clear. Among the first unexpected findings was that while wages increased throughout the 19th century, white statures paradoxically declined (Table 1; Komlos, 1987; Margo and Steckel, 1983; Costa, 1993). Other studies show that a broad set of explanatory variables were associated with 19th century stature variation (Steckel, 2009). Better nutrition corresponds with taller average statures (Komlos, 1987; Haines et al., 2003). Exposure to disease and physically rigorous work regimens are associated with shorter statures. Average stature was also related with other characteristics, such as socioeconomic conditions, business cycles, and other measures for economic performance (Voth and Leunig, 1996; Leunig and Voth, 2001; Leunig and Voth, 2006; Oxley, 2003, 2006; Steckel, 2009, p. 7; Woitek, 2003; Sunder and Woitek, 2005; Strauss, 1995; Svedberg, 2000; Steckel, 1983; Cavelaars et al., 2000; Alter and Oris, 2008). Still other studies rely more heavily on biological explanations, specifically solar radiation, human biology, and vitamin D production, and a stature–insolation relationship suggests there is a positive relationship between stature and vitamin D production (Carson, 2008, 2009). Insolation is the incoming direct sunlight that reaches the earth, its atmosphere, and surface objects. The primary source of vitamin D is the synthesis of ultraviolet B and cholesterol, and insolation is the primary source of ultraviolet B. Vitamin D_3 is made in the skin when ultra violate radiation penetrates the skin and is absorbed by 7-dehydrocholesterol (7-DHC) in the epidermis and dermis to form pre-vitamin D_3. Photosynthesis of vitamin D_3 in the skin depends upon season and latitude, time of day, and on the amount pigment and thickness of the skin (Lips, 2006; Mawer and Davies, 2001). Nonetheless, these stature–insolation studies rely on a single population and are yet to be confirmed across independent samples.

* Tel.: +1 432 552 2195; fax: +1 432 552 2174.
E-mail address: carson_s@utpb.edu
[1] Research Fellow, University of Munich, CESifo, Shackstrasse 4, 80539 Munich, Germany.

1053-5357/$ – see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.socec.2010.12.016

Table 1
Comparison of 19th century white stature studies.

Study	Birth period	Sample	ΔStature	Farmer stature advantage
Sokoloff and Villaflor (1982)	1720–1753	Military, French and Indian War	2.5 cm	.07–.88 cm
Margo and Steckel (1983)	1820–1840	Military, Civil War, adult	.483	1.21
Komlos (1987)	1820s–1870s	Military, west point, youth	.720	Na, but +
Steckel and Haurin (1994)	1845–1900	Military, Ohio national guard	−1.27	1.40
Komlos and Coclanis (1997)	1830–1930	Military, the citadel	6.60	Na
Sunder (2004)	1830–1860	Prisoners, Tennessee	1.27	Na
Carson (2008)	Youth, 1840–1900	Prisoners, Missouri	Youth, .397	Youth, .285
	Adult, 1820–1890		Adult, .657	Adult, .794
Carson (2008)	Youth, 1810–1890	Prisoners, Pennsylvania	Youth, .880	Youth, 1.92
	Adult, 1780–1880		Adult, −1.44	Adult, 1.26
Carson (2009)	1800–1899	Prisoners, United States	−1.63	1.21
Carson (2009)	Youth, 1850–1900	Prisoners, Texas	Youth, −.245	Youth, 1.88
	Adult, 1820–1895		Adult, −1.01	Adult, 1.58

Notes: Sokoloff and Villaflor (1982), Table, p. 462, time trend for native laborers and foreign artisans; Carson (2009), US prisoners, p. 155; Carson (2008), Missouri prisoners, pp. 598–599; Carson (2008), Pennsylvania prisoners, pp. 362–365; Steckel (1994), pp. 160–161; Steckel and Haurin (1994), p. 124; Komlos (1987), p. 901. Birth decade is stature averaged across ages in 1820 and 1870; Komlos and Coclanis (1997), p. 100. The Citadel is stature by birth decade; Margo and Steckel (1983), pp. 169–170, Table 1. Non-farm is weighted average of the intercepts. Sunder (2004).

This study draws upon two large 19th century stature data sets—white Civil War recruits and white state penitentiary inmates—to assess factors associated with white stature variation and to determine if the stature–insolation hypothesis is observed across two independently collected samples. Three paths of inquiry are considered. First, how did 19th century white statures compare between two different socioeconomic groups? This paper demonstrates that the statures of soldiers and prisoners were similar throughout the 19th century. Second, how did soldier and prisoner statures vary with insolation, the primary source of vitamin D? The relationship between stature and insolation for Civil War soldiers and 19th century prisoners were remarkably similar, and sensitivity analysis demonstrates that stature–insolation effects were similar between soldiers and prisoners. Third, for both soldiers and prisoners, what was the relationship between stature and occupation? The farmer stature advantage among soldiers was comparable to the farmer stature advantage among prisoners, indicating the relationships between stature, insolation, and socioeconomic status were similar across two independent 19th century samples.

2. Data

Testing the stature–insolation hypothesis across independent samples requires three unique data sources. First, a reasonable measure for solar radiation is necessary. Second, two independently drawn stature samples are required. Military records represent biological living conditions among a higher socioeconomic segment of society, and prison records represent conditions among a lower socioeconomic status segment of society.

2.1. United States' insolation

Calcium and vitamin D are two chemical elements required throughout life for healthy bone and teeth formation; however, their abundance are most critical during younger ages (Wardlaw et al., 2004, pp. 394–396; Tortolani et al., 2002, p. 60). Calcium generally comes from dairy products, and vitamin D in not dietary but is produced by the synthesis of cholesterol and sunlight in the epidermises' stratum granulosum (Holick, 2007b; 2004, pp. 363–364; Nesby-O'Dell et al., 2002, p. 187; Loomis, 1967, p. 501; Norman, 1998, p. 1108; Holick, 2007a,b). Greater direct sunlight (insolation) produces more vitamin D, and vitamin D is related to adult terminal statures (Xiong et al., 2005, pp. 228, 230–231; Liu et al., 2003; Ginsburg et al., 1998; Utterlinden et al., 2004)[2]. After the circulatory system contains sufficient amounts of vitamin D and to avoid vitamin D toxicity, vitamin D production is restricted within the stratum granulosum and residual vitamin D is broken down into inert matter (Holick et al., 1981, pp. 591–592; Jablonski, 2006, p. 62; Holick, 2001, p. 20; Holick, 2004, p. 363). This self-limiting vitamin D effect may account for white stature variation with insolation, because at North American latitudes whites are close to the natural threshold where vitamin D production is curtailed (Jablonski, 2006, p. 62; Carson, 2009, pp. 150 and 154). At the opposite extreme, insufficient vitamin D has been linked to rickets, osteomalasia, auto-immune diseases, and certain cancers (Holick, 2001, p. 28; Garland et al., 2006, pp. 252–256; Grant, 2003, p. 372).

To account for the relationship between vitamin D and stature, a measure is constructed that accounts for solar radiation. Vitamin D is synthesized from sunlight and cholesterol. The process that occurs is the conversion of 7-dehydrocholesterol to vitamin D by the energy of ultraviolet radiation. Insolation is an acronym for incident solar radiation, and is a measure for sunlight energy received for a given surface area at a given time. If w equals watts, m equals meters, and i equals insolation, $i = w/\mathrm{m}^2 = kwh/\mathrm{m}^2 \cdot \mathrm{day}$. Insolation and ultraviolet B are also the primary source of vitamin D production (Holick et al., 1981, p. 590; Holick, 2007a,b, p. 270). Insolation has also effect on the folic acid that may alter intrauterine development, and thus birth length and stature, and on the biomass of farm products and food availability to farmers.

Because of its distance from the equator, European insolation is comparatively low, and before their migration to North America, Europeans at low insolation latitudes had to be more efficient in vitamin D production. As early hominids migrated out of Africa to Northern latitudes, they received less solar radiation, and through the process of natural selection, darker pigmented hominids were less successful hunter-gatherers in Northern latitudes and were selected-out (Loomis, 1967, pp. 503–504).

Because US historical insolation is unavailable, a modern insolation index (1993–2003) is constructed, and monthly insolation values are measured from January to June. The insolation index measures statewide average insolation levels across each of the states based on the hours of direct sunlight per day at county centroids in each state[3]. Each state estimate was then determined

[2] Carson (2009), pp. 150 and 154 demonstrates that 19th statures were related to various factors, including the primary source of vitamin D production (insolation).

[3] Insolation is not the insolation in the county that surround's the state's centroid, but insolation in each county's geographic center. The range of state insolation val-