Physical and Socioeconomic Characteristics at Young Age as Predictors of Survival to 100: A Study of a New Historical Data Resource (U.S. WWI Draft Cards)

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Abstract

Centenarians (persons living to age 100 and over) represent a population that could be useful in identifying factors leading to long life and avoidance of fatal diseases. This study explores whether people living to 100 and beyond were any different from their peers at their middle age (30 years) in terms of their physical characteristics (height and body build), occupation and marital status.

A random representative sample of 240 men born in 1887 and survived to age 100 was selected from the U.S. Social Security Administration database. These records of men with exceptional longevity were then linked to the U.S. WWI draft registration cards collected in 1917 when these men were 30 years old. This allowed us to validate 171 cases of exceptional longevity, and obtain information on vital characteristics of male centenarians when they were young adults. Randomly selected shorter-lived men matched with centenarian men by birth year, race and county of draft registration were used as controls. This approach allowed us to eliminate confounding effects of birth cohort, race and place of draft registration on survival. It was found that the "stout" body build (being in the heaviest 15 percent of the population) was negatively associated with survival to age 100 years. Both farming and having a large number of children (4+) at age 30 significantly increased the chances of exceptional longevity by 100-200 percent. The effects of immigration status, marital status and body height on longevity were less important, and they were statistically insignificant in the studied data set. This study provides the first estimates of height, body build and other vital characteristics for the future centenarians at their young adult ages, shows that detrimental effects of obesity may have an exceptionally long time range, and that obesity at young adult age (30 years) is predictive for almost three times lower chances of survival to age 100 years.

1. Introduction

Studies of centenarians (persons living to age 100 and over) could be useful in identifying factors leading to long life and avoidance of fatal diseases. Even if some middle-life factors have a moderate protective effect on risk of death, persons with this trait/condition would be accumulated among long-lived individuals. Thus, study of centenarians may be a sensitive way to find genetic, familial, environmental and life-course factors associated with lower mortality and better survival, which has an obvious actuarial significance.

Incorporation of physical characteristics into demographic analysis of mortality widens a scope of explanatory variables in biodemographic research on health outcomes (Crimmins and Seeman, 2000). This study investigates the effects of the physical traits—height and body "build" at young adult age (30 years)—on the chances of survival to age 100.

An individual's height at young adult age seems to be a good indicator of a person's nutritional and infectious disease history at least in historical data (Elo and Preston, 1992; Alter, 2004; Alter, Neven, et al., 2004). Most studies, starting with Waaler's pioneer work, found a negative relationship between body height and mortality later in life (Waaler, 1984; Elo and Preston, 1992). A study of Union Army veterans found that the relationship between height and subsequent mortality was negative (Costa, 1993; Fogel and Costa, 1997; Costa and Lahey, 2005), findings similar to a study of modern Norwegian males (Costa, 1993; Costa, 1993; Fogel and Costa, 1997; Costa and Lahey, 2005). Infectious diseases (and diarrheal diseases in particular) can result in growth retardation, leading to shorter adult height. For example, conscripts from high-mortality districts of antebellum New York were shorter than those from healthier districts (Haines, Craig, et al., 2003).

In addition to nutrition and disease exposure, height is also dependent on genetics. Heritability estimates for body height are one of the highest when compared to heritability estimates for other human quantitative traits. However, genetic influence may be suppressed by environmental factors, such as poor nutrition or early infections in the past (Lauderdale and Rathouz, 1999).

It is not clear what the body size of centenarians was during their adult ages. Historical studies suggest that centenarians may be taller than average due to better nutrition and avoidance of diseases early in life (Haines et al., 2003; Alter, 2004). The proposed study tested this hypothesis.

Adult body height is affected by both environmental (early-life nutrition and exposure to infections) and genetic factors. It was found that familial resemblance in height was suppressed in the past possibly because of early environmental effects (Lauderdale and Rathouz, 1999). It was suggested that population of the United States at the end of the 19^{th} century had relatively good nutritional status but very high burden of infections (Preston and Haines, 1991). Thus, we may hypothesize that low height of males born in the end of the 19^{th} century may be related to the infectious diseases during childhood. If the hypothesis of childhood infections as a possible cause of late-life chronic diseases is correct (Finch and Crimmins, 2004), we may expect that centenarians at young adult ages would be taller on the average than their peers who did not survive to advanced ages. According to this hypothesis "chronic inflammatory mechanisms drive much of the influence of early-life infections on later morbidity and mortality" (Finch and Crimmins, 2004), and "height is also linked to infections and the inflammatory response [in childhood]," because "if infections occur during development, substantial energy is reallocated at the expense of growth, as required by the body for immune defense reactions and for repair" (Crimmins and Finch, 2006). Thus, one may expect that centenarians should be taller at their young adult ages, because, according to this hypothesis, they should have less childhood infections, which are detrimental both for body growth and subsequent longevity.

Alternatively, if biological hypothesis about adverse effects of rapid catch-up growth on longevity is correct (Rollo, 2002), we may expect the opposite result. This biological study found that the peak body mass (maximum mature mass, which reflects juvenile growth rates) was negatively associated with longevity within two studied biological species—laboratory rats and mice (Rollo, 2002). Thus, if the same relationship is applicable to humans, then centenarians should be smaller on average at their young adult ages when compared to the control population.

These hypotheses inspired us to initiate the current study on the role of body size at young adult ages as a predictor of exceptional human longevity. For this purpose, a new research approach has been applied using data from the WWI civilian draft registration cards.

2. Methods

Our previous study (Gavrilova and Gavrilov, 2007) explored new opportunities provided by the ongoing revolution in information technology, computer science and Internet expansion for studies of exceptional human longevity. Specifically, it explored the availability and quality of computerized online family histories (genealogies) of long-lived individuals by cross-checking them with other Internet resources, including the Social Security Administration (SSA) Death Master File (DMF) and early U.S. censuses.

In summation, this earlier study (Gavrilova and Gavrilov, 2007) developed a new methodology of using online genealogical, historical and demographic data resources; demonstrated feasibility of large-scale studies on predictors of human longevity; and yielded preliminary findings on several hypotheses on the determinants of survival to advanced ages (Gavrilova and Gavrilov, 2005; 2007). These earlier studies also allowed us to learn about the existence of the U.S. WWI Civilian Draft Registration Cards, their recent availability online and their rich content in terms of predictor variables, which made this study possible.

2.1 WWI Civilian Draft Registration Cards as Data Resource on Person's Height, "Build" and Other Physical Characteristics

In 1917 and 1918, approximately 24 million men born between 1873 and 1900 completed draft registration cards. President Wilson proposed the American draft and characterized it as necessary to make "shirkers" play their part in the war. This argument won over key swing votes in Congress.

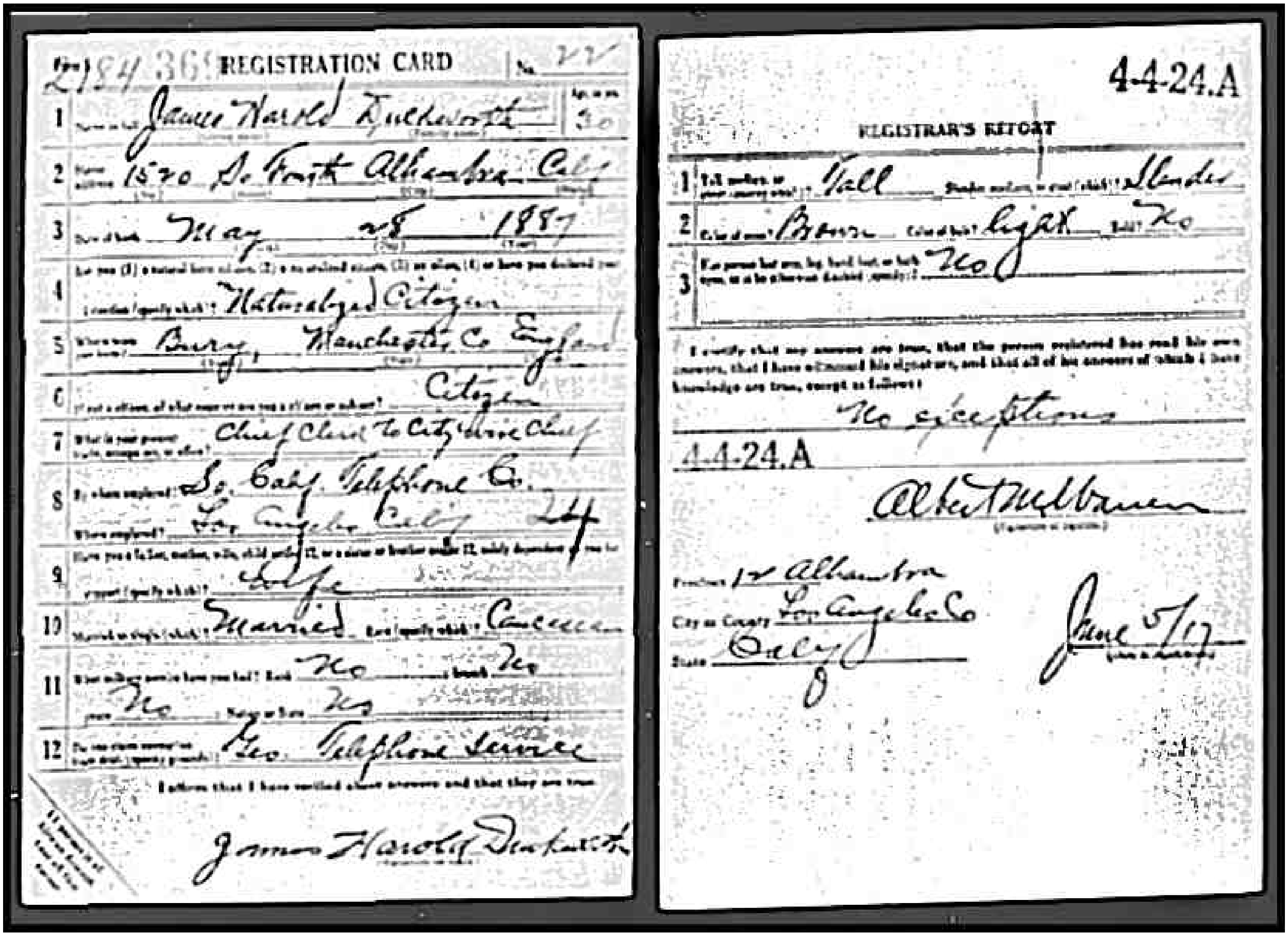
Men already on active duty in the military were excluded from draft registration. Registration of eligible men has been determined to be close to 100 percent, which means that about 98 percent of adult men under age 46 living in the United States in 1917-18 completed registration cards (Banks, 2000). Instructions for filling in each question on the card were posted for all to read at each registration site, and the local newspapers sometimes printed copies of sample cards in the days prior to registration. In the vast majority of cases, volunteer staff at the local office filled in the information on the card, and the registrant then signed his name. Men who registered were given certificates to prove they had registered. More detailed description of this data source is available in a seven-volume set, which is a part of ongoing study by Raymond H. Banks (Banks, 2000). Table 1 describes information available in the draft registration cards.

TABLE 1
Information Available from the WWI Draft Registration Cards

Group	**Description**
Core demographic data	age, date/place of birth, race, citizenship
Geographical data	permanent home address
Working characteristics	occupation, employer's name
Family characteristics	Marital status, information about dependents
Physical characteristics	height (3 categories: tall, medium, or short), build (3 categories: slender, medium, or stout), eye color, hair color, baldness, disability

The WWI civilian draft registration cards are available now online through the paid service provided by Ancestry.com. Figure 1 shows an example of electronic image of a draft registration card available at the Ancestry.com Web site.

FIGURE 1
An Example of World War I Draft Registration Card


REGISTRATION CARD

2184 369 No. 22

1 James Harold Duckworth — 30
2 1570 So. Fourth Alhambra Calif
3 May 28 1887
4 Naturalized Citizen
5 Bury, Manchester Co England
6 Citizen
7 Chief Clerk to City Service Chief
8 So. Calif. Telephone Co.
Where employed? Los Angeles Calif 24
9 Wife
10 Married — Caucasian
11 No — No
No — No
12 Gen. Telephone Service

I affirm that I have verified above answers and that they are true.

James Harold Duckworth

4-4-24.A

REGISTRAR'S REPORT

1 Tall — Slender
2 Brown — light — No
3 No

I certify that my answers are true, that the person registered has read his own answers, that I have witnessed his signature, and that all of his answers of which I have knowledge are true, except as follows:

No exceptions

4-4-24.A

Albert McIlvaine

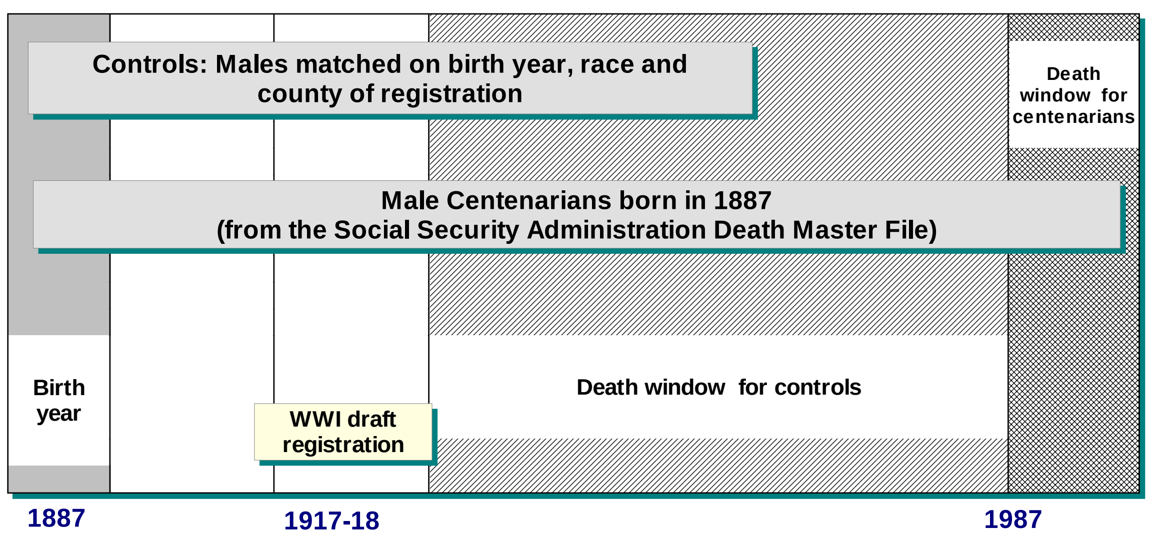
Precinct 1st Alhambra
City or County Los Angeles Co
State Calif

June 5/17

Thus the linkage process was facilitated by availability of online indexes and actual digitized images of draft registration cards. The linkage process was facilitated by the fact that the exact birth date (day, month and year) is provided both in the WWI draft cards and the Social Security Administration Death Master File, in addition to person's names, allowing us to obtain unambiguous matches in the majority of cases.

Matched Case-Control Study Design. The study applied a *matched case-control design* where shorter-lived males matched with centenarian males by birth year, race and county of draft registration were used as controls (see Figure 2). This design was initially suggested by Preston and colleagues (1998) for study of survival to age 85. This approach allowed us to eliminate effects of birth cohort, race and place of draft registration on survival. Using controls from the same geographical area (county) allowed us to mitigate a possible geographically related subjectivity in height and build estimation.

FIGURE 2
Matched Case-Control Design of the Study



The development of the study sample was conducted in three stages:

- In the first stage, records of 240 males born in 1887 and survived to age 100 were randomly selected from the Social Security Administration Death Master File (DMF). Men born in 1887 reached age 30 in 1917, so their adult height has been attained by the time of draft registration. Taking into account that DMF covers 93-96 percent of deaths of persons aged 65+ (Hill and Rosenwaike, 2001), it was possible to apply a simple random sampling design for male centenarian data. 1887 birth cohort may be considered practically extinct in 2007, because it is highly unlikely that any man born in 1887 would live more than 120 years. Thus, we may expect that DMF contains records on almost all American centenarians born in 1887, which is another advantage of selecting 1887 birth cohort for this study. The DMF database contains about 2,500 death records of male centenarians born in 1887. Due to limited resources available for this study, we used a sample of 240 (9.6 percent) randomly selected male centenarians born in 1887.

- In the second stage, the selected records were linked to the WWI civilian draft registration cards available online (a service provided by the Ancestry.com).
- In the third stage, each centenarian record has received matched control record randomly selected from the civilian draft registration records of persons of the same birth year, race and county of registration. Selecting matched control individuals from the same county of registration allowed us to reduce regional effects on the studied variables (height, build, eye/hair color, disability status, citizenship status, occupation and marital status).

2.2 Model Specification

The statistical analyses were performed using a conditional multiple logistic regression model for matched case-control studies to investigate the relationship between an outcome of being a case (survival to age 100) and a set of predictor variables (Breslow and Day, 1993; Hosmer and Lemeshow, 2001). An important advantage of conditional logistic regression is its high statistical power (Woodward, 2005), which allows researchers to detect statistically significant effects even in samples with relatively small size.

When each matched set consists of a single control (1-1 matched study), the conditional likelihood is given by:

$$\prod_i \left(1+\exp(-\beta'(x_{i1}-x_{i0})\right)^{-1}$$

where x_{i1} and x_{i0} are vectors representing the prognostic factors for the case and control, respectively, of the *i*th matched set (Hosmer and Lemeshow, 2001). A subset of confounding variables was preselected for possible inclusion in a multivariate model on the basis of their univariate analysis. Computations were conducted using Stata 10 statistical package (StataCorp, 2007).

We began with a reduced model, which included build and occupation (specifically farmer occupation). Then a set of family-related predictor variables and immigration status were added. Finally predictor variables describing other person's physical characteristics (height, eye/hair color and disability status) were added to the model.

3. Results

Overall linkage rate to the draft registration card data was 72.5 percent (174 linked records). It should be noted that not all centenarians found in DMF could participate in the WWI draft registration. Study of additional data sources revealed that two persons in the DMF sample served in the regular army during the draft registration, seven persons had their SSN issued after 1955 (suggesting late immigration), and in six cases we found misprints in SSA DMF (persons in fact were born in 1987 according to their death certificates). Elimination of these non-eligible cases increased the linkage success to 77.3 percent. Further analysis revealed very high proportion of persons with Eastern European, Italian and Spanish surnames among non-linked records (41 percent) compared to persons linked to the WWI draft registration records (only 9 percent). This suggests that many persons in the non-linkage group could immigrate to the United States after 1917. This suggestion was further confirmed by information about foreign-born status among draft registration controls.

Table 2 describes demographic and socio-economic characteristics of cases and controls.

TABLE 2
Characteristics of Men Born in 1887 and Participating in the World War I Draft Registration (in the Studied Sample)

	Proportion (percent)	
Characteristic	Centenarians (cases) N=171	Controls N=171
Race		
white	93.57	93.57
black	5.26	5.26
other	1.17	1.17
Foreign born	20.47	22.22
Married	68.42	63.74
Had children*	52.63	42.11
Farmer by occupation	31.55	23.35
Reported disability	7.02	8.77

* p=0.051 for difference between cases and controls

Note that the proportion of foreign-born individuals is similar in both cases and controls. Thus, we may conclude that the linkage success of centenarian cases to the WWI draft registration cards was not lower for foreign-born individuals compared to native-born persons. Proportions of foreign-born individuals in our sample are very close to the official data. For example, according to the 1920 U.S. census, the proportion of foreign-born individuals in age group 20-44 was 17.7 percent (U.S. Department of Commerce, 1929), which is close to our estimates. Proportion of blacks in age group 20-44 was 9.8 percent according to the same census (U.S. Department of Commerce, 1929). Taking into account higher mortality of blacks compared to whites, it is reasonable to expect decreasing proportion of blacks among centenarians (as s the case in our sample, see Table 2). Comparison to official data suggests that the linkage of centenarian records to WWI draft registration cards was not subjected to significant biases regarding foreign-born status or race.

Table 3 demonstrates distribution of cases and controls according to three categories of height and three categories of body build. Note that the “tall” category corresponds to the top 35 percent of the tallest men in the control population and the “short” category corresponds to the bottom 9th percentile of control population. Similarly, “stout” body build corresponds to the top 15th percentile of the “fattiest” men in control population, while “slender” body build corresponds to the bottom 25th percentile of male population according to their body build (see Table 3).

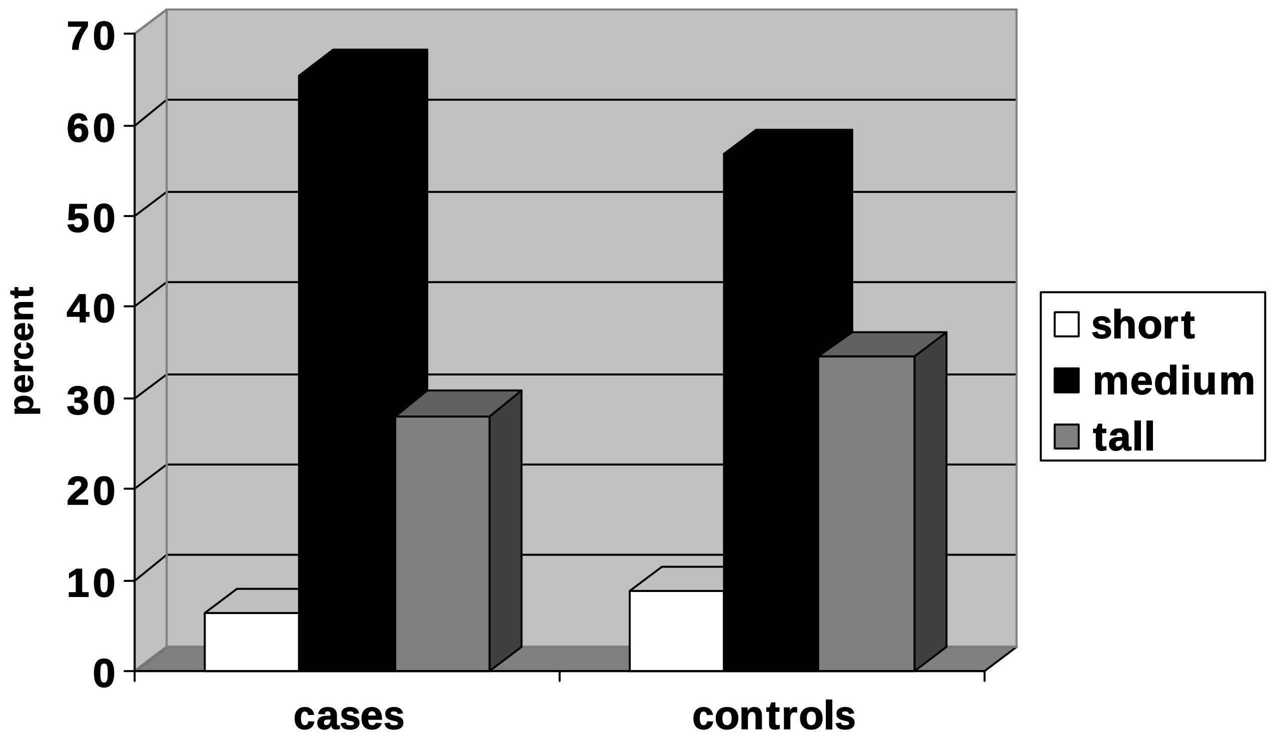
TABLE 3
Distribution of Men Born in 1887 and Participating in the World War I Draft by Height and Build Categories (in the studied sample)

	Proportion (percent)	
Characteristic	Centenarians (cases) N=171	Controls N=171
Height		
short	6.43	8.77
medium	65.50	56.73
tall	28.07	34.50
Build*		
slender	25.15	25.15
medium	67.84	60.23
stout	7.02	14.62

* p=0.07 for difference between cases and controls

Figure 3 shows distribution of long-lived and control groups according to their height at age 30.

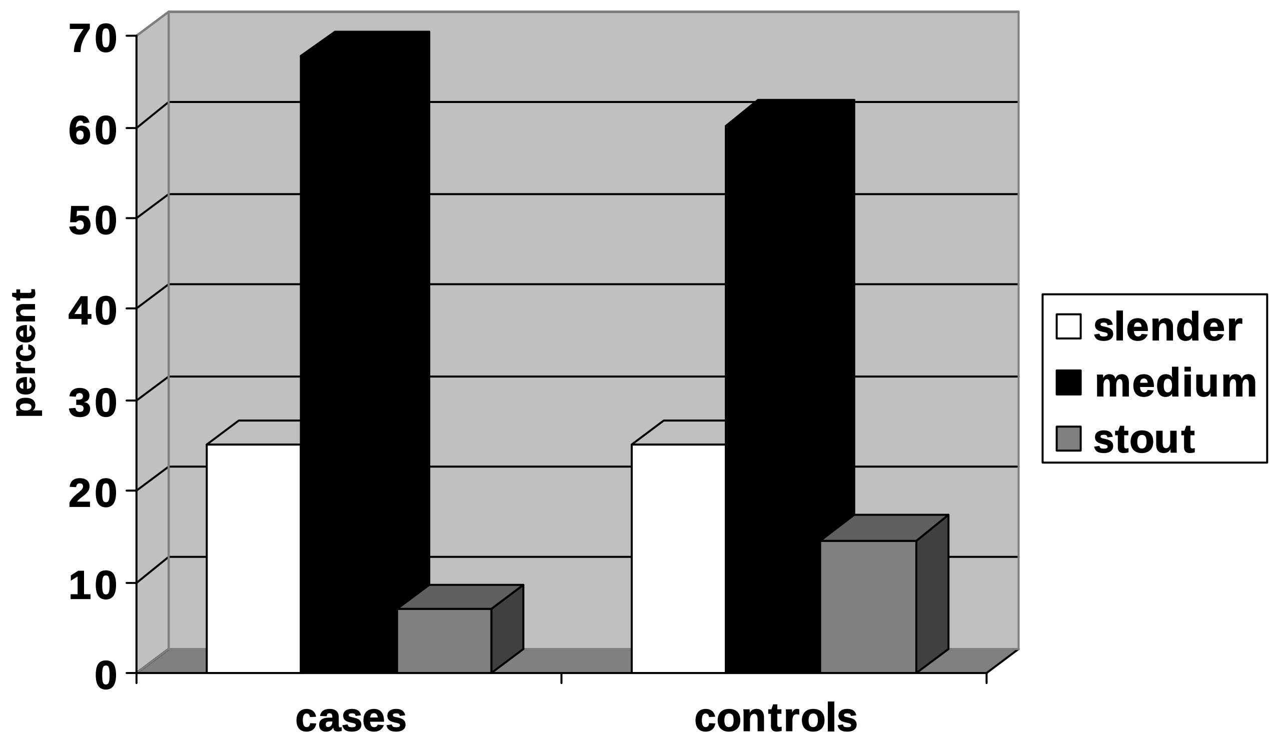
FIGURE 3
Body Height at Age 30 and Survival to Age 100. Distribution of Cases (Future Centenarians) and Controls by the Height Category



It is interesting to note that centenarians were not among the tallest men at age 30. In fact, most of them tend to be of medium height, although these differences were not statistically significant.

Distribution of centenarians and controls by their body build at age 30 is presented in Figure 4.

FIGURE 4
Body Build at Age 30 and Survival to Age 100. Distribution of Cases (Future Centenarians) and Controls by the Body Build Category



Only 7 percent of the future centenarians fell into the “stout” category, compared to 15 percent of the control group. The difference in body build distributions between cases and controls demonstrated borderline significance in univariate analyses (p=0.07).

Multivariate analyses using conditional logistic regression showed that stout body build shows statistically significant association with lower survival rates to age 100 in all three models (see Table 4).

TABLE 4
Odds Ratios (95% CI) of Exceptional Longevity (Survival to Age 100) for Certain Physical and Socio-Demographic Characteristics of Men at Age 30. Multivariate Conditional Logistic Regression

Characteristic	**Model 1**	**Model 2**	**Model 3**
Stout build	Reference	reference	reference
Slender or medium build	2.62* (1.19 - 5.77)	2.63* (1.17 - 5.89)	2.63* (1.13 - 6.12)
Farmer by occupation	2.00* (1.09 - 3.64)	2.03* (1.09 - 3.78)	2.20* (1.16 - 4.19)
Native born (vs. foreign born)		1.12 (0.63 - 1.99)	1.13 (0.63 - 2.05)
Married		0.76 (0.41 - 1.44)	0.68 (0.35 - 1.34)
No children		reference	reference
1-3 children		1.62 (0.89 - 2.95)	1.61 (0.87 - 2.98)
4+ children		2.71* (0.99 - 7.39)	2.59^{+} (0.92 - 7.28)
Short height			reference
Medium or tall height			1.35 (0.80 - 2.29)
Blue/grey eyes			1.71* (0.99 - 2.95)
Light hair			0.64 (0.31 - 1.32)
Disability			0.68 (0.28 - 1.66)

* $p \leq 0.05$; $^{+}$ p=0.07

Thus, the study of height and build among men born in 1887 suggests that obesity at young adult age (30 years) is harmful for attaining exceptional longevity, while body height is a far less important predictor of exceptional longevity.

Another interesting finding of this study is a positive effect of farming on survival to age 100. In addition to farming, several broad occupational groups were studied: white collar occupations (clerks, bankers, etc.), blue collar skilled occupations (repair mechanics, machinists), service occupations (grocers, barbers, salesmen) and unskilled occupations (laborers, kitchen hand, etc.). None of these occupational groups had a significant effect on attaining longevity in our study.

Being married by age 30 had no statistically significant effect on survival to age 100. However the number of children at age 30 demonstrated an obvious positive effect on chances of exceptional longevity (see Table 4). Draft registration cards recorded all proband's children below age 12. Taking into account that it seems unlikely for men to have children older than 12 at age 30 (which corresponds to fatherhood before age 18 years), we may suggest that draft registration cards reported almost all existing children for men in our sample. It is interesting to note that a large initial number of children born by age 30 increases man's chances to attain exceptional longevity by a factor 2.6 – 2.7 (Table 4).

4. Discussion

Our findings that "stout" body build predicts much lower survival rates to 100 years are generally consistent with the existing knowledge that particularly high body mass index (BMI) and obesity are associated with increased mortality (Flegal, Graubard, et al., 2005; Adams, Schatzkin, et al., 2006; Flegal, Graubard, et al., 2007). Our findings also expand this knowledge further in three ways: 1) the detrimental effects of obesity may have an exceptionally long time range, that is obesity at young adult age (30 years) is still predictive for decreased chances of survival to age 100 years; 2) the significance of body build as predictor of exceptional longevity is much higher than all other potentially important variables, such as body height, immigration status, marital status and professional occupation (with exception that being a farmer is highly beneficial for attaining exceptional longevity); 3) contrary to expectations based on life extension of calorically restricted animals, a "slender" body build does not improve chances of survival to 100 years.

A number of limitations of the data need to be considered in evaluating the results related to body build and height characteristics. Although draft registration cards contain valuable information on individual physical markers, this resource is not free of limitations. The main difficulty we face here is using height and build data measured in a categorical rather than continuous scale—in three broad categories, which are less precise than measures provided in specialized health surveys like NHANES. During the WWI draft registration, local staff was asked to classify individual men as to height and weight. The three categories provided were rather vague, and occasionally the staff wrote in actual weight and height instead. In addition to this, some errors in reporting physical characteristics were also mentioned (Banks, 2000). Nevertheless, the data were measured by the volunteer staff in the registration office at the time when centenarians were young adults and hence are not subjected to self-report and recall bias. Also, using county-matched controls helps to avoid possible regional differences in defining "tallness" or "shortness." This study provides the first estimates of height and build for the future centenarians at their young adult ages and useful methodology for subsequent large-scale studies on middle-life predictors of exceptional human longevity.

Another interesting result of our study is a positive and significant effect of farming on survival to age 100. This result is consistent with our previous findings suggesting that children raised on farms (boys in particular) had higher chances to become centenarians (Gavrilova and Gavrilov, 2007). Similar results were obtained by other authors who studied childhood conditions and survival to advanced ages and also found much stronger effects of farm childhood on longevity for men than women (Preston, Hill, et al., 1998; Hill, Preston, et al., 2000; Stone, 2003). Preston and colleagues (Preston, Hill, et al., 1998) suggested a hypothesis that farm childhood effect on longevity is stronger for men compared to women because men raised on farms become farmers by occupation and continue to live on farms in healthier environments. Our findings presented here are consistent with this hypothesis.

Positive association of the number of children with longevity found in this study seems to contradict the predictions of some evolutionary theories of aging (disposable soma theory) claiming that longevity comes at the cost of decreased reproduction (Westendorp and Kirkwood, 1998). On the other hand, this finding may have reasonable explanations, both of social and biological nature. First, a large number of children being born earlier in life may provide a necessary caregiving and material support for the parent at his older ages. Second, high fertility at young age may be a marker of man's overall good health (Gavrilova and Gavrilov, 2005). Further studies of centenarians including studies of genealogical data may shed more light on the mechanisms of this interesting phenomenon.

The results of this study demonstrate the usefulness of the U.S. WWI draft registration cards as a new promising source of information for finding the factors associated with lower mortality and better survival, which has an obvious actuarial significance.

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