PAA paper for Session 172:
Early Life Conditions and Adult Health

Midlife Predictors of Exceptional Longevity: A Study of the US WWI Draft Registration Cards

Natalia Gavrilova, Leonid A. Gavrilov
Center on Aging, NORC and the University of Chicago

ABSTRACT

This study explores whether people living to 100 and beyond were any different from their peers at their middle age (30 years). A random sample of 240 men born in 1887 and survived to age 100 was selected from the US Social Security Administration database and then linked to the US WWI draft registration cards collected in 1917 when these men were 30 years old. Randomly selected shorter-lived men matched by birth year, race and county of draft registration were used as controls. It was found that the 'stout' body build (being in the heaviest 15% of population) was negatively associated with survival to age 100 years. Both farming and having large number of children (4+) at age 30 significantly increased the chances of exceptional longevity. The effects of immigration status, marital status, and body height were less important, and they were statistically insignificant in the studied data set.

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 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 diarrhoeal 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 19th 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 19th 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 control population.

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

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 exploratory 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; Gavrilova and Gavrilov 2007). These preliminary studies also allowed us to learn about the existence of the US WWI Civilian Draft Registration Cards, their recent availability online, and their rich content in terms of predictor variables, which made this study possible.

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%, which means that about 98% of adult men under age 46 living in the U.S. 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 About Here

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

Figure 1 About Here

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, 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 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.

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 limited sample by 240 (9.6%) 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).

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, Lemeshow, 2001). A subset of confounding variables was pre-selected 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, disability status) were added to the model.

RESULTS

Overall linkage rate to the draft registration card data was 72.5% (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 2 persons in DMF sample served in regular army during the draft registration, 7 persons had their SSN issued after 1955 (suggesting late immigration) and in 6 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%. Further analysis revealed very high proportion of persons with Eastern European, Italian and Spanish surnames among non-linked records (41%) compared to persons linked to the WWI draft registration records (only 9%). 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 About Here

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, proportion of foreign-born individuals in age group 20-44 was 17.7% (U.S. Department of Commerce 1929), which is close to our estimates. Proportion of blacks in age group 20-44 was 9.8% 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 it is 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 3 categories of height and 3 categories of body build. Note that the 'tall' category corresponds to the top 35 percent of the tallest men in 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 About Here

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

Figure 3 About Here

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 About Here

Only 7% of the future centenarians fell into the 'stout' category, compared to 15% 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 About Here

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 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.). Neither 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 effects 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 rather unlikely for men to have children older than 12 at age 30 (corresponding 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 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) .

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 do 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 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 US 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.

Acknowledgements

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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

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

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).

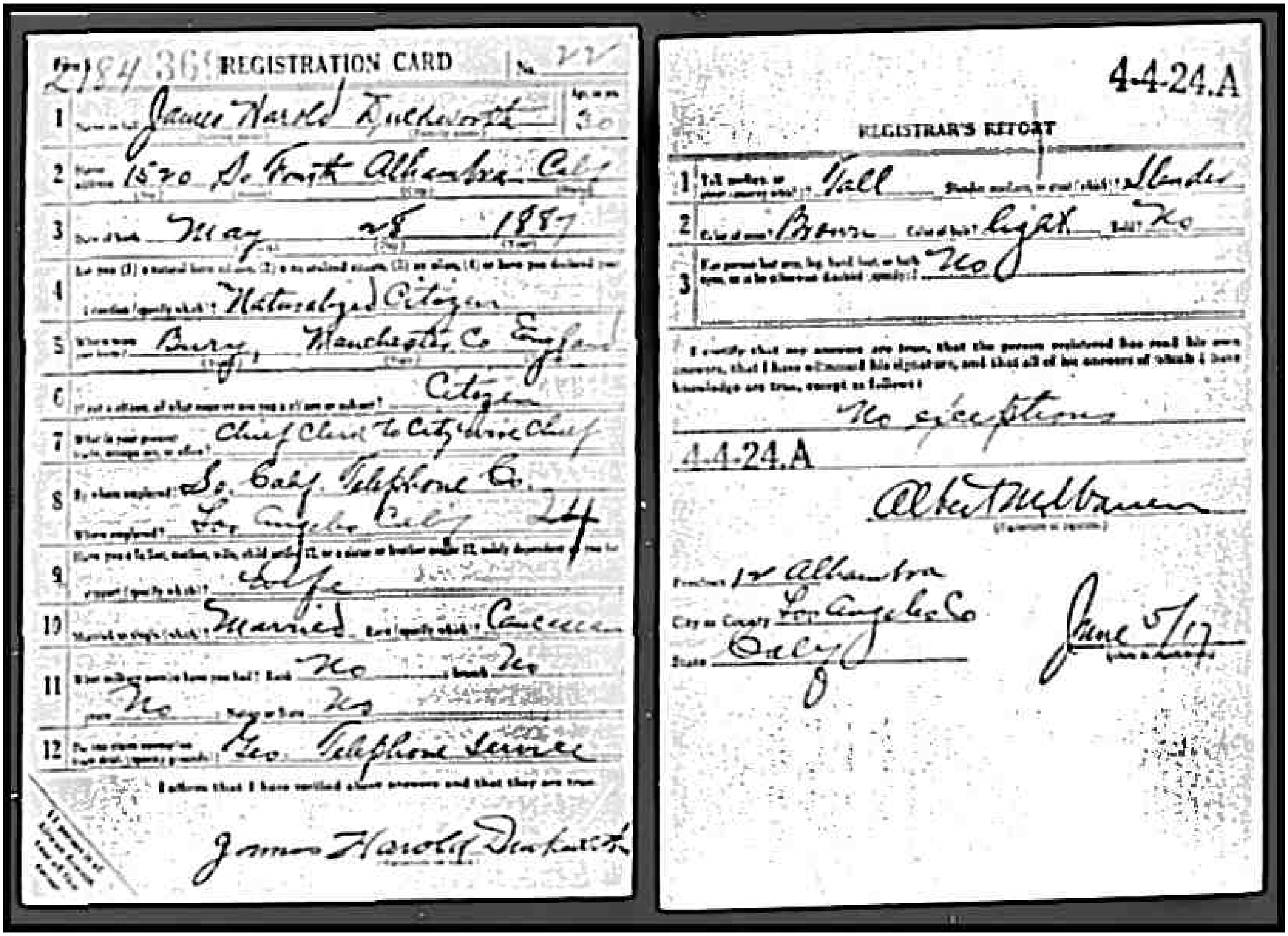
	Proportion (percent)	
Characteristic	Centenarians (cases) N=171	Controls N=171
Height		
short	6.43	8.77
medium	65.50	56.73
tall	28.07	34.50
Build*		
slender	25.15	25.15
medium	67.84	60.23
stout	7.02	14.62

* p=0.07 for difference between cases and controls

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



REGISTRATION CARD

1 James Harold Duckworth 30

2 1570 So. Forth Alhambra Cal.

3 May 28 1887

4 Naturalized Citizen

5 Bury, Manchester Co England

6 Citizen

7 Chief Clerk to City Wire Chief

8 So. Cal. Telephone Co. Los Angeles Cal. 24

9 Wife

10 Married Caucasian

11 No No No No

12 Tel. 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 McIlbraun

Precinct 1st Alhambra

City or County Los Angeles Co

State Calif.

June 5/17

Figure 1. An example of World War I draft registration card.

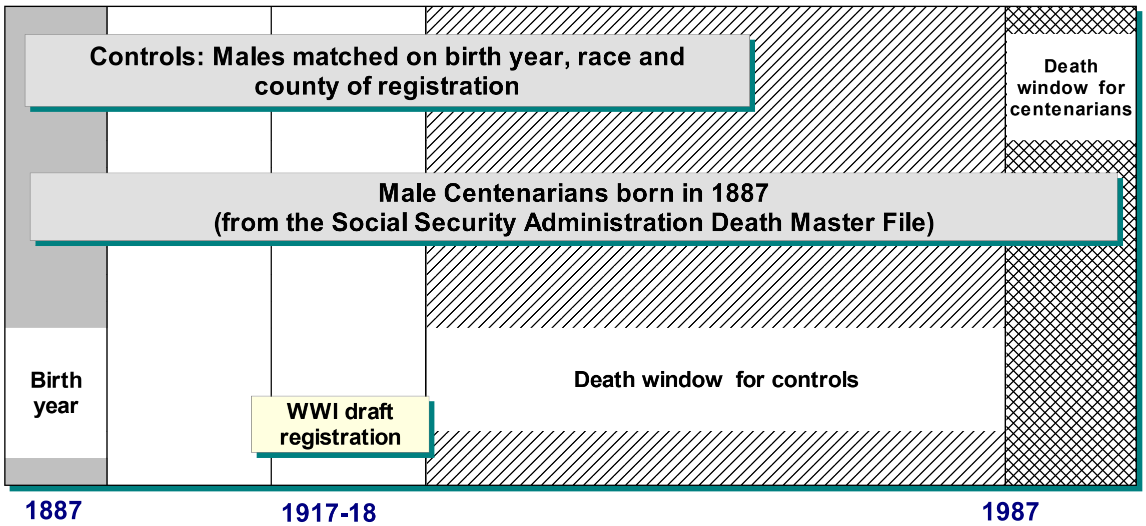


Figure 2. Matched case-control design of the study.

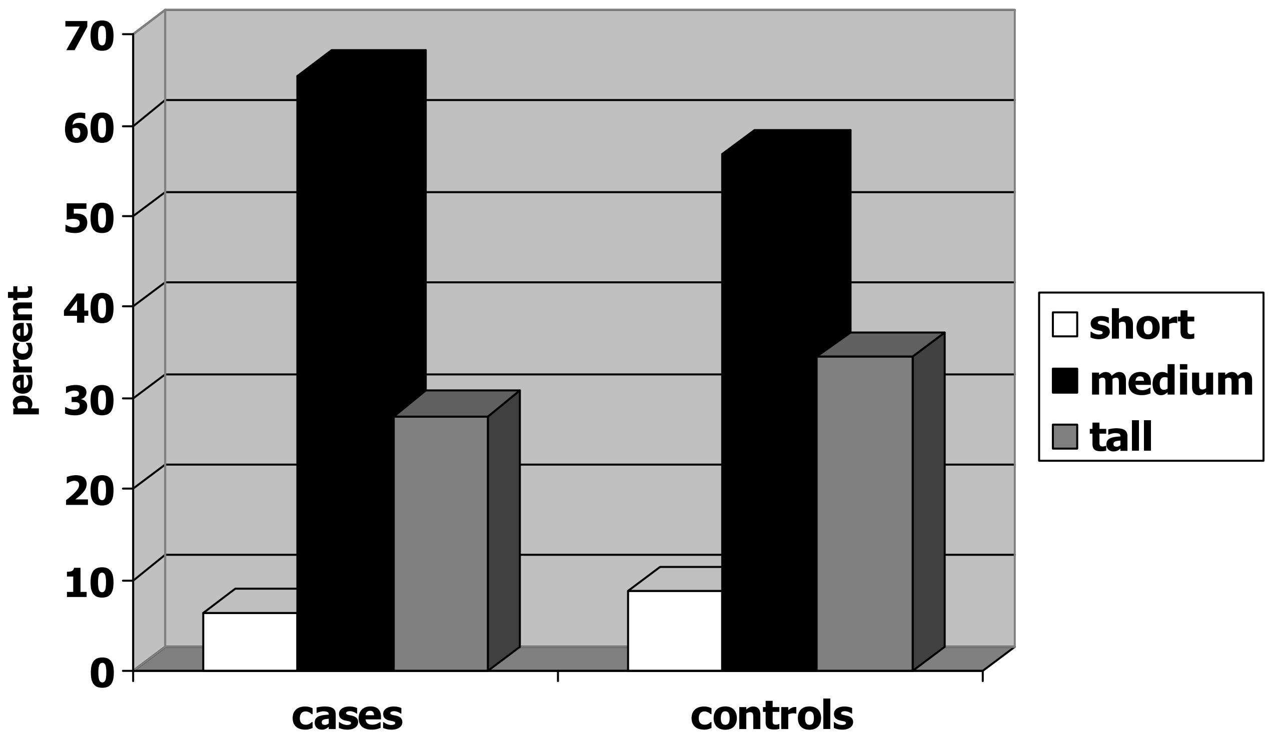


Figure 3. Body height at age 30 and survival to age 100. Distribution of cases (future centenarians) and controls by the height category.

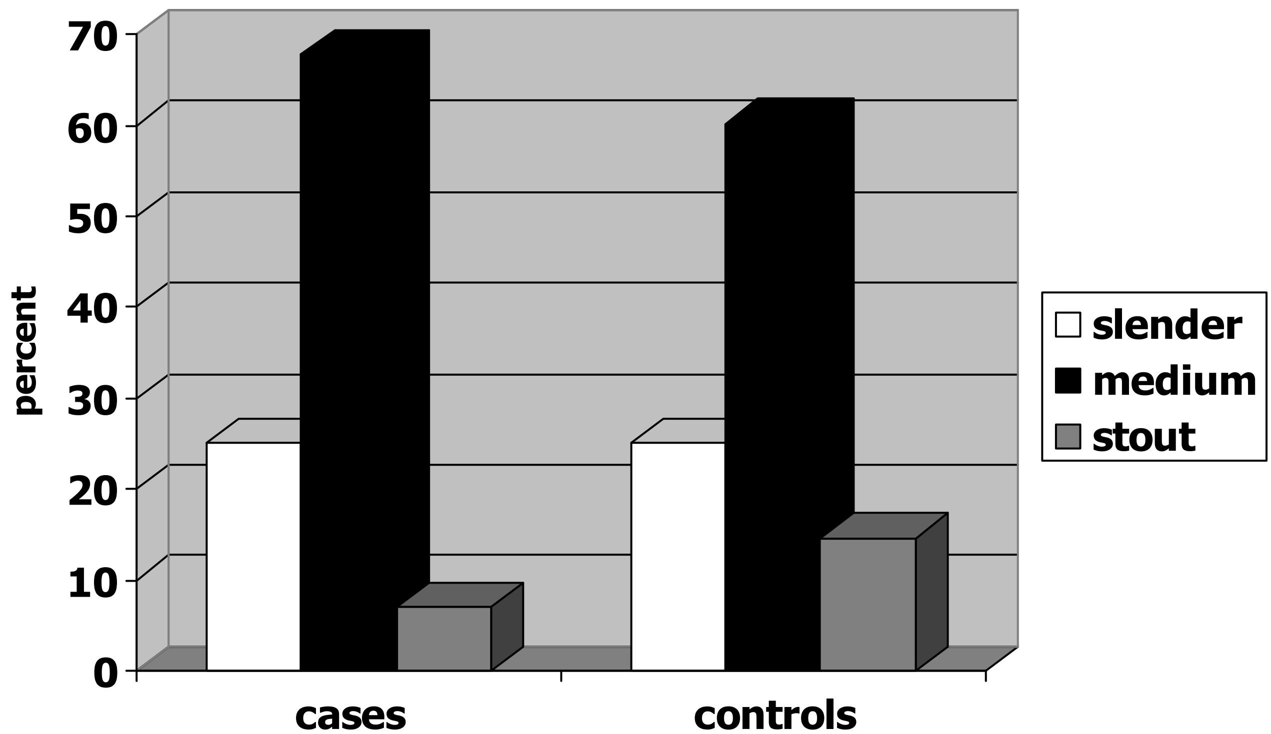


Figure 4.
Body build at age 30 and survival to age 100. Distribution of cases (future centenarians) and controls by the body build category.