TITLE

Association of Leg Length with Mortality: Evidence From NHANES I

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ABSTRACT

In recent years, epidemiologic and demographic studies have tried to explain the association between early childhood conditions and health outcomes in adulthood. Empirical evidence from England has shown that leg length provides an indication of better pre-pubertal nutrition which may suggests that childhood exposures might influence adult disease risk (Gunnell 2001).

This paper aims to examine the relationship between leg length and adult mortality in the U.S. Preliminary results suggests that, although measures of leg length are significantly different between males and females in NHANES I, using Gompertz proportional hazard models we show that there is no overall association between leg length and the hazard of death in adult U.S. population. When we analyzed leg length by race and gender, there is an association between this measure and the hazard of death for black males only, although the relationship is rather weak. In further analysis will control for unobserved heterogeneity at older ages.

INTRODUCTION

In recent years, epidemiologic and demographic studies have tried to explain the association between early childhood conditions and health outcomes in adulthood. Some researchers have traced a number of those conditions as far back as the fetal stage (Barker 1992), the in-utero separation and postnatal stage (Gunnell 1999). Others have looked at the relationship between mothers and their babies (Barker 1997), childhood energy intake, and childhood diet (Frankel et al. 1998; Maynard 1999), among other factors. Nevertheless, it is not clear what conditions in childhood can be associated with adult health outcomes.

It has been shown that childhood height is associated with prenatal growth (Leitch 1951), parental height (Gunnell 1998), child's health (Smith 2001), and nutrition (Cooper 1996). Among components of stature during childhood (trunk length and leg length), leg length is the component responsible for the greater part of pre-pubertal height increases. Thus, leg length may provide an indication of better pre-pubertal nutrition which may suggest that childhood exposures influence adult disease risk (Gunnell 2001). Empirical evidence, mainly from British studies, suggests that leg length is the component of adult stature most strongly associated with measures of childhood diet and socioeconomic status, and that leg length appears to be a particular sensitive indicator of childhood socioeconomic circumstances (Gunnel et al. 1998).

Adult leg length has been associated with a variety of health conditions in adulthood: diabetes (Kousta et al. 2000; Lawlor et al. 2002), insulin resistance (Smith et al. 2001), blood pressure (Langenberg et al. 2002), coronary heart disease(Lawlor et al. 2004), cancer (Gunnell et al. 2001) and mortality (Gunnell et al. 1998).

Despite the empirical evidence of the association of leg length and health outcomes later in life for the British population, there have been no attempts to show whether similar associations exist for other populations, particularly, in the U.S.

This paper aims to examine the relationship between leg length and adult mortality in the U.S.

The main research questions we address are:

1) Is there a relationship between adult leg length and adult mortality in the U.S. population? How does this research compare to prior studies using British populations? If results are inconsistent, what socio-demographic characteristics at childhood (e.g. prevalence of infectious diseases, nutrition, poverty) account for different findings in these two populations given that empirical evidence comes from birth cohorts born before 1950?

2) If leg length is the component of adult stature most strongly associated with measures of childhood diet and socioeconomic status, and given that we are analyzing an American population born before 1950, we expect a differential effect of leg length on mortality by race and gender. In other words, are there any racial and gender differences in the U.S. so that leg length is associated with mortality for particular races or a particular gender only?

These results should be of interest to those who study the impact of childhood on adult health, with particular emphasis in mortality. The results should also be of interest to policy makers looking at the conditions of childhood that may have a differential impact on adult mortality by race and gender.

DATA

The data in our study comes from the Nutrition, Health and Examination Survey I (NHANES I), 1971-1975 (anthropometry component) and its epidemiologic follow-up in 1992 (vital status and mortality components). This survey was conducted between April 1971 and June 1974 on a probability sample of the U.S. noninstitutionalized civilian population ages 1 to 74. It was designed to measure the nutritional status and health of the U.S. population ages 1 to 74 and to obtain more detailed information on the health status and medical care needs of adult ages 25 to 74. The NHANES I epidemiologic follow-up in 1992 use as a baseline those adult persons aged 25 to 74 who were examined in the NHANES I and collected information on changes in the health and functional status of the entire nondeceased cohort since last contact. The 1992 follow-up includes subjects who were deceased at the time of the follow-up of the 1982-84, 1986 and 1987 as well as subjects who were not known to be deceased prior to the 1992 follow-up.

We are interested in the demographic (age, sex, marital status, education etc.), anthropometric (height, sitting height, leg length) and health measurements (weight, subscapular skinfolds, and triceps skinfolds) of people aged 35 and older at NHANES I and their vital status (death/alive) at the epidemiologic follow-up in 1992. The selected sample consists of 10671 people who were known to be death or alive[1] at the time of the epidemiologic follow-up in 1992; among those selected, 42% have died and 57% were still alive in 1992. More than half of the deaths come from males (58%), while almost two-thirds of people who were alive are women (65%). Overall, the sample consisted of approximately 38% of females and 20% of males alive, and 19% and 23% of female and male deaths, respectively.

[1] The sample excludes those individuals whose vital status in 1992 is unknown. The "alive" vital status includes those who were interviewed, as well as those who were traced alive with direct subject contact but lost prior to the interview, and those traced alive without direct subject contact and lost prior to the interview.

METHODOLOGY

The first step is an analysis of leg length by birth cohort and gender. After the descriptive analysis, we will use survival analysis techniques. The analysis time will be age on the x-axis; therefore, Gompertz proportional hazard (PH) models by gender and race will be used to account for the effect of leg length on the hazard of death, controlling for demographic (marital status, place of residence, etc.) and health variables (skinfold measures, and BMI).

In addition to the previous analysis, we will use Gompertz PH models with gamma frailty component to account for the unobserved heterogeneity in mortality, particularly at older ages.

PRELIMINARY FINDINGS

Some of our results from NHANES I study include:

(1) Using Gompertz PH models we found that there is no overall association between leg length and the hazard of death in adult U.S. population. Comparing leg length measures of British vs. American population we found that leg length shows higher variability among female British participants. This may suggest differential effect of socioeconomic conditions for those two populations before 1950. Further analysis to identify socioeconomic conditions in both population around 1950 will be pursued.

(2) Trends in leg length are significantly different between males and females in NHANES I. While leg length shows a monotonic increase for males; for females the pattern is not that obvious. Leg length increases between females born in 1900-1905 relative to 1896-1900, decreases for the next cohort (although its value is still larger than in 1896-1900) and then reduces even more, reaching its lowest level at birth cohort 1910-1915. After 1915, leg length rises moderately up to 1920-1925, and increases again for each birth cohort following 1925, reaching a plateau after this point. Even though the range of the mean leg length for females is quit low (1.1 cm.), an analysis of variance (ANOVA) confirms that the mean leg length is statistically different among birth cohorts for females, and the same result holds for males. Separate analysis was performed for race and gender separately.

<u>Gompertz PH models with no frailty component by race and gender:</u>

(3) There is no association between leg length and mortality for whites. For white females, trunk length has a statistically significant effect on the hazard, in which every 10cm. increase (5 in.) in trunk length will imply a reduction of about 1.6% on the hazard. Nevertheless, leg length does not show a significant effect. For white males, neither sitting height nor leg length is associated with the hazard of death.

(4) Leg length is the only anthropometric measure associated with mortality for black males although this effect is marginally significant at the 10% level. None of the components of height (leg length and sitting height) have an effect on the hazard for black females. Males whose leg length is in the fourth quartile show a higher hazard of death when compare to those at the first quartile. For every 10 cm. increase (5 in.) in leg length for those in the fourth quartile, their hazard increases by about 3.6% relative to those in the first quartile.

Further analysis including a frailty gamma component in the Gompertz PH model will account for the unobserved heterogeneity at older ages.

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