Tallness comes with Higher Mortality in Two Cohorts of US Army Officers

paper submitted for presentation at the Population Association of America Meeting 2009

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Abstract

In general, taller people have a lower general morbidity and mortality, the only notable exception being cancer. The underlying causality is complex, because all relevant factors: genetics, nutritional status in childhood, upward social mobility for tall people, fewer health hazards, better medical care for high status people are highly intercorrelated. Here we study two special samples: graduates of the classes of 1925 and 1950 from the U.S, Military Academy at West Point, retired without disability after 20+ years in active service, followed up to mid 2008. These men had been rigorously selected for health and fitness, subjected to a healthy lifestyle, and medically well cared for. Consequently the variability of most intervening variables is low. The taller half of both samples had an excess mortality 60+, but cancer related only in the younger cohort. Reported higher cancer risk among tall people may exist only for cohorts born after WWI.

Introduction

Taller people usually live longer than shorter members of their community, for reasons not fully understood. Adult height is negatively correlated with many diseases frequent in both sexes in rich countries in East and West [1]. These include cardiovascular conditions like coronary heart disease, cerebrovascular conditions like stroke, and respiratory disease [2-10]. Height is also associated with known risk factors [11-13], also accidents, violence [5], and suicide [10,14]. The most important exception is cancer. Robust positive associations have been found between height and several sites of cancer: breast, prostate, colon, rectum, endometrium, kidney, and cervix, as well as adenocarcinomas and haematopoietic cancer [15-23]. That lung, stomach, or oesophageal cancer [20] is more common among short people, probably is caused by life style factors more common among low social status groups in which people tend to be shorter anyway [1].

Consequently, short stature often is associated with a higher general mortality and a shorter life span [24], a relationship that holds in premodern societies too [25]. A few authors, notably T. T. Samaras [26-30], have contrary evidence from special populations where those short in stature have lower mortality than taller people, or from special samples from general populations, where the inverse association between height and mortality does not exist. Clearly, differences within groups may have other causes than differences between groups. Authors who reported the positive association between height and cancer in general population samples, found no such association in a large socially homogeneous sample of individuals who attended the University of Glasgow 1948-1968 [31]. In that cohort they found differences in health-relevant behavior among courses of study, which perhaps are responsible for differences in cause-specific mortality. For example, former law and arts students had excess mortality from cardiovascular disease, while former medical students had less lung cancer but higher alcohol-related mortality from suicide, accidents, and violence [32].

Excluding growth deficiency disorders, there are several causal mechanisms potentially linking height to morbidity and mortality. The effect of genetics on height is considerable [33-34], and early childhood nutritional status can be influential even under non-extreme conditions [20]. Tall people, especially men, have an advantage in achieving high social status [35], leading to fewer health hazards and better medical care. While some diseases (e.g. lung cancer) are predicted by social status of patients, other diseases (e.g. coronary heart disease) are better predicted by social status of parents [36]. Given assortative mating with respect to height [37-38], and the strong persistence of socio-economic status between parents and children[39], the ubiquitous social gradient in height [1] may have a genetic dimension. Then there are obvious cohort effects: as societies become more affluent, nutrition differentials between rich and poor narrow, and the association between social status and height via early childhood nutrition may get smaller, while other factors may become more influential.

Typical of the intricate confounding of these potential influences are the findings from the Boyd Orr Study, a long prospective study starting in Britain in the late 1930s: (1) In the ubiquitous association between socio-economic status and tallness, it is leg length, not trunk length, that matters most [40]. (2) Leg length is crucially influenced by energy intake in childhood [40]. (3) Energy intake in childhood predicts incidence of various cancer types not related to smoking [15]. (4) Probably because of (2) and (3), leg length predicts risk of cancers not related to smoking [17,19-23,41]. (5) However, intake of fresh fruit and vegetables in childhood, more frequent in high status families, may decrease cancer incidence in adult life [42]. (6) In general, total cancer incidence is higher in adults growing up in low status families [43], although (7) for some cancer types, including the most frequent ones, this social gradient may change over time [44-45]. All this ends up in an inverse statistical association between leg length and cancer incidence in the Boyd Orr sample, which reverses its direction once social status is controlled [41], although the strength of this confounder effect may be cohort dependent [40].

In view of such complex intercorrelations, controlling for intervening factors in the general population may be hopeless, even with the most sophisticated methods. Moreover, social status usually is measured by a composite of formal education, income, and occupational prestige, and does not capture the sizeable differences in health behaviour and cause-specific morbidity and mortality, such as were reported for graduates of different courses at Glasgow University [32]. A more promising approach is to study special populations where some of these factors have much lower variability over the life course, and then consider how to generalize the findings.

Studying the association between height and morbidity / mortality is important for applied and basic research:

First, if childhood nutrition is the common causal factor behind the association, then either feeding children so that they reach their growth maximum – or conversely, if not tall, but short stature is associated with better health – subjecting them to caloric restriction to a degree that their body length growth is affected would be a preventive measure of choice.

Second, for research in health inequality in a life course perspective the development of health and lifespan differentials by height would be vital information.

Third, identifying height as risk factor for any disease may give important hints for the aetiology of the disease, in particular if not only the outcome – adult height – but the emergence of the risk can be ascribed to certain stages in body development.

Fourth, tallness has been shown to come with increased reproductive success for males with no adverse effects for females [46], with highest benefit for the tallest men. This suggests a unidirectional selection for tallness, for which curiously no apparent check has been found yet. Studying the height – health association in a population where short men are as healthy, have been fed as well during childhood, and as adults have the same chances for social success as tall men, may provide crucial information for solving this riddle.

Data and Methods

Here we analyse the height-mortality association in graduates of the United States Military Academy at West Point, specifically the classes of 1925 (n=245) and of 1950 (n=670). The annual *Register of Graduates and Former Cadets* [46], and obituaries in the academy's alumni magazine, *Assembly* [47], provide vital data and information on each man's performance at the academy and during active military service. Occasional data discrepancies with the Social Security Data Base were resolved in favour of highly reliable academy sources. We know years of birth, of leaving the military (discharged, resigned, retired disabled or not disabled), and of death (including whether killed in action). We also know each cadet's General Order of Merit (GOM), a ranking at graduation based on academic, athletic, and leadership performance. GOM is a strong predictor of war college attendance and final military rank.

We do not have a direct measure of height but do have a suitable proxy in the cadet's company assignment while at West Point. Prior to 1957, the academy assigned cadets to companies according to their height so that they would present a uniform appearance on the parade grounds. This sorted the men into six (class of 1925) and twelve (class of 1950) ordered categories of height. Each company had the same number of cadets. Our use of company membership as a proxy for height is equivalent to using "percentile" values, which is frequently done in regression models. Probably this produces betas that are equal or slightly lower, and p-values equal or slightly higher, than if absolute height were entered into the models.

Since cadet ranks and assignment at graduation to a particular service (Air Force or Army) or branch (Artillery, Infantry, etc.) were distributed across companies, these are unrelated to height. The men of 1925 were born between 1897 and 1904, those of 1950 between 1923 and 1929. Birth year is unrelated to height (1925: r=.069, p=.300; 1950: r=.040, p=.420).

Height admission limits at West Point after WWII was 62–78 inches (157 – 198 cm). We do not know if there is a difference in mean height between our study samples and the general male U.S. population of the same age, but we assume that variance in the general male population is greater, so any tallness effect on mortality may be greater in the general population than in our West Point group.

In 1991, to supplement publicly available data, we mailed a questionnaire about family and professional matters to the 539 surviving members from the Class of 1950. We received 437 responses (81%), merging this information with public data for further analysis of the class [48-49]. Height did not predict survey participation (r=.020, p=.636) among the survivors up to 1991. The Class of 1950 is essentially middle class and almost exclusively European in origin. The fathers of survey respondents all graduated from high school, and 60% had some college; respondents' mothers all graduated from high school and 50% had some college. Respondents' first and second wives all graduated from high school and about 80% had some college. Cadets came from rural areas and had fathers who were professional soldiers more often than the average adolescent (with height unrelated to either variable), but otherwise they were not conspicuously different. Each respondent's country of ancestry was coded as East, North, South or West Europe. Those with North European ancestry were tallest, then West, East, South, but ancestry had no effect on career success, reproductive success, or mortality, and was dropped from further analysis. We do not have similar information for The Class of 1925, but given the strong prevalence of Anglo-Saxon names, it is unlikely that this class was more ethnically diverse than their successors 25 years later.

In order to control for extraneous variability, we selected the 124 men of the class of 1925 and the 438 men of the class of 1950 who had retired without disability after an uninterrupted military career of at least 20 years, when they could retire with benefits. These men remained fairly evenly distributed over height categories. Height did not predict death while on active service (including war).

Graduation from a war college is a prerequisite for promotion to the highest military ranks. Therefore we equate career success with military rank attained at the time of retirement plus whether or not the respondent graduated from a war college. In both classes, 13% of all graduates reached the rank of general, making these classes among the most successful in West Point history.

Unlike many civilian settings, career success in both samples was virtually unrelated to height [48-49]. In the 1950 sample, belonging to the first height quartile (the shortest quarter) slightly diminished chances to get a third or fourth star as general, but not chances to be promoted to one- or two-star general rank. In the 1925 sample, even this slight handicap for short men did not exist. Higher ranks enjoyed lower mortality between ages 60 and 80, but not later. This has been shown to be mostly a selection effect [50-51], probably based on the advantage of robust health for promotion to the highest ranks. In both cohorts, height did not predict age at retirement.

Overall, the samples are uniquely valuable because they are from a population in which variation in several major intervening variables is kept at a minimum. (1) Virtually all men came form a stable middle class background with a European ancestry, grew up in peacetime, and apparently experienced no extreme hardship in childhood. (2) All men, the short as well as the tall, were highly screened for physical and mental fitness, and intelligence before admission to West Point. (3) All men remained healthy and fit at least until their retirement.[1] (4) Men's weight

[1] All US Army service personnel – active and reserve - twice per year have to take the Army Physical Fitness Test with three moduls: with depending on age 42 (17-21years) - 16 (62+years) push-ups in two minutes; 53 - 26 sit-ups in two minutes, two miles run in 15:54 - 20:00 minutes as the required minimum performance for males. If a soldier has a permanent medical condition that keeps him or her from conducting the two mile run, an alternate aerobic event (2.5 mile walk, 800 yard swim, or 6.2 mile bike) is taken. There are no alternate events for the push-up or sit-up [53]. This test has been administered ever since the Korean War with little modifications in the US Army. Similar tests are used in the Navy, the Air Force and the Marine Corps.

would have conformed with the *United States Army Maximum Allowable Weight (MAW) Table*, with MAWs corresponding to a BMI of 29.9 for the shortest and 27.9 for the tallest men [52]. (5) Unlike many civilian professions, tallness does not improve career success. (6) Junior officers have the greater risk of being killed in war, but otherwise, in the microcosm of military compounds, rank differences have no impact on nutrition, sanitation, or exercise facilities, with free and excellent health care, and regular mandatory check-ups for all. (7) Income inequality is moderate. The basic monthly salary of a four-star general at present is about twice the salary for a major, the lowest final rank observed among those with 20+ years of service in both samples, and in any case, well above the poverty line.

Results

In both samples, height was virtually unassociated with mortality before age 50. Among older men, height differences in cumulative survival do appear. We applied nonparametric models (life table), semiparametric (the Cox proportional hazard rate model), and the Gompertz Makeham survival-function parametric model. In the tests of the semi- and full parametric models, rank and war college attendance is always used as a control variable, although we know that in this special population, height is unrelated with rank.

Table 1 shows, for each class, the cumulative survival and hazard rate for all subjects, by age, for all men who retired without disability after 20 and more years of service. Men are divided into shorter and taller halves.

For the Class of 1925, shorter men had the advantage in cumulative survival, especially between ages 60 and 90. By age 90 there is a reversal, but this involved very few survivors. A statistical comparison of survival experience, using the Wilcoxon (Gehan) test, yielded a statistic of 6.687 at one degree of freedom, or p=.001. For the semi-parametric and parametric models, we tested the 10-year age interval during which the mortality differentials by height group were maximal. This was the age interval 63-72. A Cox model showed the cumulative survival advantage for short men to be significant at p=.050 [exp(B)=2.480]. For the same age interval, a Gompertz Makeham model showed the advantage for short men to be significant at p=.052 (B=0.8340).

For the Class of 1950, shorter men had an advantage in cumulative survival after age 60. A statistical comparison of survival experience, using the Wilcoxon (Gehan) test, yielded a statistic of 3.338 at one degree of freedom, or p=. 0677. As before, we applied semi-parametric and parametric models to the 10-year age interval in which mortality differentials by height group were maximal. Here the interval is 60-69 years. Since most of the graduates of 1950 are still alive, this is a provisional designation. A Cox model showed the cumulative survival advantage for short men to be significant at p=.024 [exp(B)=3.630]. A Gompertz Makeham model showed the advantage for short men to be significant at p=.046 (B=0.6331).

The shorter half in our sample from the class of 1925 had a median life span of 78 years, the taller half of 74 years[2]. We cannot calculate median life span for the Class of 1950 because most of these men are still alive. We note, however, that 84% of the shorter half have already survived to age 77, while survival among the taller half was below 84% before these men reached the age of 70.

The excess mortality among tall men in both cohorts is about in the range indicated by Gunnell et al. [17] for the excess cancer risk to taller people. This raises the obvious question, Are our observed mortality differences by height due to cancer? Ideally this could be answered through death certificates in state health department files, but in practice it is difficult to locate and gain access to these, and

[2] It would not make sense to compare these lifespan figures with the ones in the US Social Security Administration generation life tables, since in our samples we have survivors to various ages at retirement included and we have excluded death by accident or violence during active military service.

furthermore, a number of graduates died abroad. As an alternative, we consulted obituaries in the West Point periodical, *Assembly*. Typically written by relatives or classmates, these run 100-900 words and often indicate cause of death.

We located 109 obituaries for the 245 graduates of 1925 (the last class member died 2006). Causes of death are shown in Table 2a. Of the 670 graduates from 1950, 263 deaths were reported to West Point as of July 2008. We located 117 obituaries in *Assembly*, and stated causes of death are shown in Table 2b. Furthermore, we obtained cause-of-death information from the NDI, but only for the 1950 class, since in 1978, the year with the earliest entries in the NDI, almost 60% of the 1925 class were already dead.

For the Class of 1925, there is no indication of greater cancer mortality among taller than shorter men. This inference is made cautiously because there seems to be an underreporting of cancer deaths, but nothing indicates a height bias in reporting.

In contrast, for the class of 1950, tall men suffered greater cancer mortality than short men (p=.048). Only thirteen of 117 obituaries mentioned no cause of death, and there is no indication of any height bias in reporting. The proportion of cancer related deaths in this class – their youngest members are now in their 79th year - will decrease in the future, but no finding published in the literature suggests that this trend will be different among shorter as compared with taller men. In the taller as well as in the shorter half, cancer related deaths are evenly distributed over the lifespan past the 50^{th} birthday, with no concentration in the age interval 62-71 where the excess mortality of tall men has its maximum. Median age for all deaths occurring after age 50, which received an obituary making no reference to cancer, was 61 years in both height groups (n=17 in the shorter half, n=16 in the taller half). Given this small number of cases, and the fact that obituaries are often published decades after the death, the question remains open whether the longevity advantage for shorter men persists for the class of 1950 once cancer related deaths are disregarded.

Discussion

In both West Point samples, with career success controlled, tallness comes with increased general mortality after age 55. This contradicts the usual finding that taller people live longer. Probably the deleterious effect of height is seen in this study because we have reduced variation in spurious life-enhancing factors that are often correlated with height. Our samples are middle class in background with European ancestry. They comprise men highly screened for physical and mental fitness, subject to a healthy lifestyle, and medically well cared for. Height in this population had no effect on rank or income. Tall men had more children, but number of children did not predict mortality. Hardship in life before the Academy will have been much rarer than in the general population anyway. Thus, the genetics contribution to phenotype variation may be higher than in the general population.

The prediction that this excess mortality is cancer related was supported in the Class of 1950. However, with most of these men still alive, we cannot estimate whether the cancer disadvantage for taller men will fully explain the final difference in life expectancy between the tall and the short. For the Class of 1925, cancer does not explain the relationship between height and mortality. Perhaps the higher cancer risk among tall people, reported in the general population, exists only for cohorts born after 1920. Recall that in the large socially homogeneous sample of individuals who attended the University of Glasgow between 1948 and 1968, there was no relationship between cancer and height [31].

In any case, in a very homogeneous sample, with most relevant intervening variables controlled, tallness as a potentially life-shortening risk factor. In the general population, this effect may be masked by lifestyle and other life prolonging factors associated with one's own or one's parents' social status. Samaras & Storms [30] found an inverse relation between height and life span in records from the Veterans Administration Medical Center, San Diego CA. Probably this sample is like ours in selectivity for health and healthy lifestyle.

Elsewhere we show, for the Class of 1950 sample, that tallness comes with increased reproductive success: taller men had more children[46]. Higher post-reproductive mortality for tall men, reported here, may be the first trace of an evolutionary constraint on tallness, at least in males, as predicted by evolutionary theory.

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Table 1

Class of 1925 tallness: Cumulative Survival Rates

Age	Cumulative Survival Rates shorter half of class	Cumulative Survival Rates taller half of class
25	1,0000	1,0000
30	1,0000	1,0000
35	1,0000	1,0000
40	1,0000	1,0000
45	1,0000	1,0000
50	,9868	,9643
55	,9474	,9107
60	,8947	,8750
65	,7895	,7321
70	,6184	,5357
75	,4079	,3393
80	,3026	,2500
85	,1447	,0893
90	,0132	,0357
95	,0132	,0179
100,0+	,0000	,0000

Class of 1925 tallness: Hazard rate

age	Hazard rate shorter half of class	Hazard rate taller half of class
25	,0000	,0000
30	,0000	,0000
35	,0000	,0000
40	,0000	,0000
45	,0000	,0000
50	,0026	,0073
55	,0082	,0114
60	,0114	,0080
65	,0250	,0356
70	,0486	,0620
75	,0821	,0898
80	,0593	,0606
85	,1412	,1895
90	,3333	,1714
95	,0000	,1333
100,0+	**	**

Class of 1950 tallness: Cumulative Survival Rates

Age	Cumulative Survival Rates shorter half of class	Cumulative Survival Rates taller half of class
25	1,0000	1,0000
30	1,0000	1,0000
35	1,0000	1,0000
40	1,0000	1,0000
45	,9909	,9847
50	,9635	,9745
55	,9315	,9439
60	,9087	,9031
65	,8813	,8469
70	,8447	,8061
75	,8402	,8061
80	,8402	,8061

Class of 1950 tallness: Hazard rate

Age	Hazard rate shorter half of class	Hazard rate taller half of class
25	,0000	,0000
30	,0000	,0000
35	,0000	,0000
40	,0000	,0000
45	,0018	,0010
50	,0056	,0021
55	,0067	,0064
60	,0050	,0088
65	,0061	,0128
70	,0085	,0099
75	,0011	,0000
80	,0000	,0000

Table 2a
Causes of Death, Class of 1925

Cause of death mentioned in obituary	Shorter half of class	Taller half of class
No cause of death mentioned	29	20
Explicit or implicit mentioning of cancer as cause of death	4	4
Explicit or implicit mentioning of other cause of death	21	30
No obituary	72	65

(none of the row differences is significant in a chi-square Test).

Table 2b
Causes of Death as of September 2003, Class of 1950

Cause of death mentioned in obituary	Shorter half of class	Taller half of class
No cause of death mentioned	7	6
Explicit or implicit mentioning of cancer as cause of death	10	21
Explicit or implicit mentioning of other cause of death	36	37
No obituary	33	44

(only row difference in cancer mortality is significant in a chi-square Test at p=.048).