Tallness comes with Higher Mortality in Two Cohorts of US Army Officers, Which May be Only Partly Cancer Related

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Abstract

Taller people are known to have a lower general morbidity and mortality, except from cancer. Relevant factors - genetics, nutrition in childhood, higher upward mobility for tall people in many settings, fewer health hazards and better medical care for high status people, cohort effects - are highly intercorrelated. Here we study graduates of 1925 and 1950 of West Point, retired not disabled after 20+ years active service. Subjects came from middle class families, were rigorously selected for health as young adults, subjected to a healthy lifestyle regime for decades, medically well cared for ever since: The taller of both samples had an excess mortality between ages 60-75, leading to four more years lifespan for the shorter half, which is cancer related only in the younger cohort. Perhaps the higher cancer risk among tall people exists only for cohorts born after 1920. Tallness may be a mortality risk by additional mechanisms.

Introduction

Adult height since long has been known to be associated with many diseases frequent in both sexes in rich countries in East and West [1], notably cardiovascular conditions like coronary heart disease, cerebrovascular conditions as stroke, and respiratory disease [2-10] – and with according association with known risk factors [11-13], but also accidents or violence [5] or suicide [10,14]. The most important exception is cancer. Robust positive associations between height and several sites of cancer have been found: breast, prostate, colon, rectum, endometrial, kidney, cervix adenocarcinomas and haemotopoietic cancer [15-23]. The most important exceptions here are lung, stomach and oesophageal cancer [20].

Consequently, short stature often is found to be associated with a higher general mortality and a shorter life span [24], with evidence that this was so already in premodern societies [25]. Few authors, notably TT Samaras [26-30], however, have gathered contrary evidence in particular from special populations, short in stature which are shown to have a lower mortality as compared with taller groups, 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.

The same authors who wrote major papers on the positive association between height and cancer in general population samples, could find no such association in a large socially homogeneous sample of individuals who attended the University of Glasgow 1948-1968 [31]. Moreover, in this cohort they found considerable differences in health relevant behaviour between course of study, perhaps responsible for sizeable differences in cause specific mortality, for example former law and arts students having excess all cause and cardiovascular disease mortality, former medical students having lower lung cancer, but higher alcohol related mortality including suicide, accidents, violence [32].

Even with circumscript growth deficiency disorders excluded, there are several causal mechanisms linking height with morbidity and mortality:

The effect of genetics on height is considerable [33-34], but early childhood nutritional status is quite influential also under non extreme conditions [20]. In addition, tall people – especially males – in all societies have an advantage in achieving high social status [35], leading itself to fewer health hazards and better medical care. Some diseases (e.g. coronary heart disease) can be better predicted by social status of parents, other diseases (e.g. lung cancer) by social status of subjects in adulthood [36]. Given assortative mating with respect to height [37-38], and the strong socio-economic status persistence between parents and children, found even in the most egalitarian societies [39], the ubiquitous social gradient in height [1] may have a genetic dimension. Then there are obvious cohort effects: once societies are getting more affluent, nutrition differentials between rich and poor will narrow, and the association between social status and height via early childhood nutrition may get smaller, while other factors may get more influential.

Typical for the intricate intercorrelations between these potential influence factors are the findings from the Boyd Orr Study, a very long prospective study starting in Britain in the late 1930s, that (1) for the ubiquitous association between socio-economic status and tallness, it is leg length, not trunk length which also here matters [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 non smoking related cancer [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, smoking and non smoking related cancer incidence is higher in adults growing up in low status families [43], although (7) for some cancer types, among them 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 it's direction once social status is controlled for [41], whereby the strength of this confounder effect may be cohort dependent [40].

With such complex intercorrelations, controlling of such intervening factors in general population samples is hopeless even with the most sophisticated methods. 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 / mortality for example reported for graduates of different courses of study from Glasgow University [32]. A more promising approach is studying special populations where some of these factors have a much lower variability over the whole life course, and then to consider generalising 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 two data sets including all graduates of the classes of 1925 (n=245) and of 1950 (n=670) United States Military Academy at West Point, of whom we have from publicly accessible Academy sources (the Annual Register of Graduates and former cadets [47-] and obituaries from the Academy's alumni magazine ASSEMBLY [48]) the vital data, information on performance while on the Academy and during active military service. Occasional data discrepancies with the Social Security Data Base always were resolved in favour of the Academy sources, indicating their reliability. We know year of birth, of leaving the military (discharged, resigned, retired disabled, not disabled) and of death (including whether killed in action), cadet company, athletic accomplishments and GOM (the General Order of Merit, in which graduates are listed forever in the registrar of West Point graduates – by then a measure of academic, but also athletic and social accomplishments, known to be a statistically powerful career predictor), war college attendance and final rank for all members of the classes. In 1925 and 1950 the Academy still followed the practice of assigning cadets to cadet companies according to their height so that they would present a uniform appearance on the parade grounds (in 1957, "Project Equality" did away with that practice). Each company had the same number of men. A man's height did not predict which particular service (Air Force or Army) or a particular branch within a service (e.g. Armour, Artillery, Infantry etc.) he entered after graduation, which may come with different mortality rates, in war as in peacetime. The men of 1925 were born 1897 - 1904, the men of 1950 were born between 1923 and 1929, with birth year unrelated to height (1925: r=.069, p=.300; 1950: r=.040, p=.420).

We do not know if there is a difference in mean height between our study group and the general male U.S. population of their age, but we assume that variance in the general male population was greater, so the size of a tallness effect on morbidity and mortality may be greater in the general population than in our West Point group.

Height admission requirements at West Point after WWII used to be 62–78 inches (157 – 198 cm), today 60–80 inches. Exact height, while certainly in the personnel files, is not included in the public sources, and, therefore, not accessible. This need not harm. Our use of company membership is equivalent to a conversion of the original metric data into "percentile" values, which is frequently done in variety of regression models. In general, betas in such regression models tend to be equal or slightly lower, with p-values equal and slightly higher for categorised variables as compared with the original metric ones. Thus, using data transformed in our style, exposes more to the risk of underestimating rather than overestimating the true effect size in such models.

In addition, of all surviving 539 members from the Class of 1950 of the United States Military Academy at West Point, 437 (81 %) participated in a mailed survey in 1991, giving professional and family information. Using public sources, these data were merged with vital data, measures of academic, athletic, and social performance while at the Academy, available and known to predict career success [45-] (Mueller & Mazur 1996), and data on military career after graduation. Height did not predict survey participation (r=.020, p=.636) among the survivors up to 1991. The West Point Classes of 1950 is a sample of the middle class US population of almost exclusively European origin. Survey respondents' fathers all had graduated from high school with 60% of them with at least some college; respondents' mothers all had graduated from high school with 50% of them with at least some college; respondents' first wives all had graduated from high school with 85% of them with at least some college; respondents' second wives all had graduated from high school with 78% of them with at least some college. Cadets came from a rural background and had a professional soldier as father apparently more often than the average adolescent of their cohorts (with height related to neither of these two variables), but otherwise were without conspicuous selectivities. Since tallness and career chances may also be influenced by ethnicity of family of origin, each respondent's country of anchestry was coded as East, North, South or West Europe. This variable had a slight effect on height (those with North European origin were tallest, then West, East, South) but none on professional, reproductive success, nor mortality, and was dropped from further analysis.

We do not have similar information on the men of 1925, but, given the even stronger prevalence of Anglo Saxon names, reject the idea of a greater ethnic diversity as compared with their successors 25 years later.

In order to control for variations in the socio-economic environment, for this study, we selected the 124 men of the class of 1925 and the 438 men of the class of 1950 who had retired not disabled after an uninterrupted military career for at least 20 years. These men remained fairly equally distributed over the height groups.

We equated professional success with military rank attained at the time of retirement plus whether or not the respondent graduated from a war college, which is a prerequisite to promotion to the highest ranks. Of all graduates, in both classes 13% each attained the rank of general, placing both classes among the most successful in West Point history.

Unlike as in many civilian settings, career chances in active service in both samples were unrelated to height [46]. 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 brigadier or major general rank. In the 1925 sample, even that this slight handicap for short men did not exist. Higher ranks enjoyed a lower mortality between age 60 and 80, but not later any more. This has been shown to be mostly a selection effect [49-50], probably based on the advantage of robust health for promotion to the highest ranks. In both cohorts, height did not predict age at retirement.

The samples are uniquely valuable because they are from a population were variation in several major intervening variables are kept at a minimum

1. Virtually all men came form a stable middle class background with a European ancestry, grew up in peacetime and will have experienced no hardship in childhood.

2. All men, the short as well as the tall ones, were highly screened for physical (today 8 correct pull-ups and 54 push-ups in two minutes, among others - see http:\\www.usma.edu) and mental fitness, as well as intelligence before admission.

3. All men, the short as well as the tall ones, remained healthy and fit at least until their late 40s, otherwise they would not have stayed in active military service.

4. Men's BMI will always have been well within the "desirable" range as given by the 1959 "Metropolitan Desirable Weight Table", which are still referred to in the "desired weight" column (ranging from a BMI of 27.0 for the shortest and 25.1 for the tallest men) in the currently valid *United States Army Maximum Allowable Weight (MAW) Table* with MAWs ranging from a BMI of 29.9 for the shortest and 27.9 for the tallest men [51].

5. Unlike as in many civilian professions, here, tallness has been shown not to improve career chances [46].

6. Junior officers have a greater risk to be killed in war, but otherwise, in the microcosm of military compounds, rank differences have no impact on nutrition, sanitation, exercise facilities, with free and excellent health care with regular mandatory check-ups for all.

7. Income inequality is moderate: Basic Monthly Salary of an officer after 20 years of uninterrupted active service in the highest rank (4 star general: 11601,90$) in 2002 was about just twice as high as in the lowest rank observed in both samples (major: 5310,60$), in any cases a secure income well above the poverty line.

Results

In both samples, height was not associated with mortality up to age 50-55, but later on, tallness came with increased mortality between age 60 and 75.

We applied nonparametric models – life table, semiparametric models – the proportional hazard rate model (Cox models) and parametric models – the Gompertz Makeham survival function 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.

A complete table of the cumulative survival and of the hazard rate for all subjects by class, who retired not disabled after 20 years of service, is shown in Table 1. Men are divided by belonging to the lower or upper height half of the class.

Class of 1925:

Mortality differentials are maximal between 64 and 74 years of age. A statistical comparison of survival experience during the decade 64-74 years of age, using the Wilcoxon (Gehan) statistic, yielded a statistic of 6.687 at one degree of freedom, p=,.001

A semiparametric proportional hazard rate model (Cox model) gave the maximum differential mortality effect of belonging to the upper half for the 10 years interval 63 – 73 years with exp(B)=2.480 at p=.050.

A Gompertz Makeham survival function model gave the maximum differential mortality effect of belonging to the upper half for the 10 years interval 63 – 73 years with B=0,8340 at p=.052.

Class of 1950:

Differentials are maximal between 63 and 73 years of age. A statistical comparison of survival experience during the decade 63-73 years of age, using the Wilcoxon (Gehan) statistic, yielded a statistic of 3.338 at one degree of freedom, p=. 0677.

A semiparametric proportional hazard rate model (Cox model) gave the maximum mortality effect of belonging to the upper half for the 10 years interval 60 – 70 years with exp(B)=3.630 at p=.024.

A Gompertz Makeham survival function model gave the maximum differential mortality effect of belonging to the upper half for the 10 years interval 62 – 72 years with B=0,6331 at p=.046.

Since the youngest surviving members of this class now still are before their 75th birthday, future analysis may find the age interval with the maximal height dependent mortality differential to be located even later in life.

The shorter half in our sample of the class of 1925 had a median life span of 78 years, the taller half of 74 years[1]. The proportion of survivors in the shorter half in our sample of the class of 1950 up to age 76 (at the completion of this manuscript, seemingly no classman has yet died at an older age) is 84%. In the taller half in the class of 1950 sample, this mark was crossed at age 70. Since this gap can be expected to narrow somewhat at older ages, the best estimate may be that also in the younger cohort, who might end up with about 10 more life years than the older cohort, in which the mark of 82% survivors was crossed at age 63, belonging to the shorter half may give you four more years in comparison to the taller half.

In the age interval 60-75 cancer is the most frequent cause of death, and the excess size – see table 1 – is about in the range as indicated by Gunnell et al. [17] for the cancer risk of taller people. Thus, the obvious next question is, whether this mortality differences by height in our two cohorts are related to cancer.

Access to death certificates of in state health department files is difficult and restricted for deaths in recent years. Also, a number of graduates have died abroad. An alternative are obituaries from ASSEMBLY, the Association of Graduates' quarterly, containing 100-900 words, written by relatives or classmates.

[1] 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.

Of the 245 graduates of the class of 1925 – no survivors any more – there are 109 obituaries. The causes of death mentioned in these obituaries are distributed as shown in table 2a. Note that, here, all graduates of that class are listed.

(Insert Table 2a about here)

Of the 670 graduates of the class of 1950, 194 deaths have been reported to West Point sources until mid September 2003; of these, there are 117 obituaries in ASSEMBLY. The causes of death mentioned in these obituaries are distributed as shown in table 2b. Note that, here, all graduates of that class are listed.

(Insert Table 2b about here)

For the class of 1925, it is difficult to argue in favour of a greater cancer mortality risk among taller men. Clearly, there is an underreporting of cancer deaths, but nothing indicates that this should be more frequent among taller men. The greater proportion of obituaries without any cause of death mentioned among the shorter men cannot, however, be used for arguing in the opposite direction, since non cancer related causes are less frequently mentioned for shorter men, while mentioning cancer is evenly distributed. Height did not predict getting an obituary. For the class of 1925, from these figures it is safest to assume that cancer mortality was not associated with height.

For the class of 1950, on the other hand, a greater cancer mortality risk among taller men is likely. Underreporting of causes of death is low (13 out of 109 obituaries) and evenly distributed by height. Height did not predict getting an obituary. The proportion of cancer related deaths in this class – their youngest members are now in their 75th 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. Since obituaries are often published decades after the death, the data for the class of 1950 unfortunately still do not allow to assess whether a longevity advantage for shorter men persists once cancer related deaths are not considered.

Discussion

Both samples, displaying an almost exclusive middle class background with European ancestry, are drawn from a population highly screened for health, physical and mental fitness, subjected for most of their active life a healthy lifestyle regime, and medically very well cared for through their whole lifetime. Since these men had lived their whole life under conditions optimal for their cohort, they will have reached their maximum height. Height in this population had no effect on rank and income. Tall men had more children, but number of children did not predict mortality. Thus, the genetics contribution to phenotype variation might be higher than in the general population. We find that, with own professional achievements controlled, in both samples, tallness comes with increased general mortality after age 55.

The prediction that this excess mortality is cancer related, with West Point sources could be supported only in the younger cohort. Furthermore, at present it is not possible to estimate whether the cancer related longevity disadvantage of taller men in the younger cohort will fully explain the observed app. four years difference in life expectancy as compared with shorter classmen. In the older cohort, this difference cannot be explained by cancer mortality differentials anyway. All this raises the important question whether the higher cancer risk among tall people reported in general population samples may exist only for cohorts born after 1920. Remember that in the large socially homogeneous sample of individuals who attended the University of Glasgow 1948-1968, such an association could not be identified, too [31]. Tallness may increase mortality through additional causal mechanisms.

In any case, in a very homogeneous sample, with most relevant intervening variables controlled, we have identified tallness as a potentially life shortening risk factor. This fact in general samples may typically be masked by life style and other life prolonging factors associated with own and/or 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 a sample comparably selected for health and healthy lifestyle as ours. One the other hand, for the younger sample, we showed that tallness comes with increased reproductive success, the taller the more [46]. The positive mortality differential by height in postreproductive life, reported here, may be the first trace of an evolutionary constraint on tallness, at least in males, which has been predicted by evolutionary theory, but has not been found so far.

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Table 1
Class of 1925 tallness: Cum survival

Age	Cum survival shorter half of class	Cum survival taller half of class
25,0	1,0000	1,0000
30,0	1,0000	1,0000
35,0	1,0000	1,0000
40,0	1,0000	1,0000
45,0	1,0000	1,0000
50,0	,9868	,9643
55,0	,9474	,9107
60,0	,8947	,8750
65,0	,7895	,7321
70,0	,6184	,5357
75,0	,4079	,3393
80,0	,3026	,2500
85,0	,1447	,0893
90,0	,0132	,0357
95,0	,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
25,0	,0000	,0000
30,0	,0000	,0000
35,0	,0000	,0000
40,0	,0000	,0000
45,0	,0000	,0000
50,0	,0026	,0073
55,0	,0082	,0114
60,0	,0114	,0080
65,0	,0250	,0356
70,0	,0486	,0620
75,0	,0821	,0898
80,0	,0593	,0606
85,0	,1412	,1895
90,0	,3333	,1714
95,0	,0000	,1333
100,0+	**	**

Class of 1950 tallness: Cum survival

Age	Cum survival shorter half of class	Cum survival taller half of class
25,0	1,0000	1,0000
30,0	1,0000	1,0000
35,0	1,0000	1,0000
40,0	1,0000	1,0000
45,0	,9909	,9847
50,0	,9635	,9745
55,0	,9315	,9439
60,0	,9087	,9031
65,0	,8813	,8469
70,0	,8447	,8061
75,0	,8402	,8061
80,0	,8402	,8061

Class of 1950 tallness: Hazard rate

Age	Hazard rate shorter half of class	Hazard rate taller half of class
25,0	,0000	,0000
30,0	,0000	,0000
35,0	,0000	,0000
40,0	,0000	,0000
45,0	,0018	,0010
50,0	,0056	,0021
55,0	,0067	,0064
60,0	,0050	,0088
65,0	,0061	,0128
70,0	,0085	,0099
75,0	,0011	,0000
80,0	,0000	,0000

Table 2a

	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

	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).