Biodemography and Social Biology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hsbi20

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Available online: 24 Apr 2012

To cite this article: Luisa Salaris, Michel Poulain & Thomas T. Samaras (2012): Height and Survival at Older Ages among Men Born in an Inland Village in Sardinia (Italy), 1866-2006, Biodemography and Social Biology, 58:1, 1-13

To link to this article: http://dx.doi.org/10.1080/19485565.2012.666118

Biodemography and Social Biology, 58:1–13, 2012

ISSN: 1948-5565 print / 1948-5573 online
DOI: 10.1080/19485565.2012.666118

Routledge
Taylor & Francis Group

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This study investigated the relationship between individual height and survival at older ages among conscripts born between 1866 and 1915 in an inland village of Sardinia, Italy. Individual age at death was related to military height measurement at age 20. Differential longevity of conscripts at older ages was investigated through the comparison of age-specific mortality rates and life expectancy estimates. Results indicated that short conscripts (<161.1 cm) generally had higher survival rates than their tall peers (≥161.1 cm). At 70 years of age, tall peers were expected to live two years less than short conscripts. Biological mechanisms were examined in relation to the greater longevity of shorter people.

In Sardinia, individuals from the inland village Villagrande Strisaili are on average shorter than their Sardinian and national peers (Piras et al. 2006). From a demographic point of view, this population belongs to the *Blue Zone*—an area with higher longevity compared to the rest of the island and mainland Italy (Poulain et al. 2004). In Sardinia, it has been observed that areas where the population exhibits greater longevity correlate with areas where the population is of shorter height (Salaris et al. 2006). This study adopted a longitudinal approach to determine whether height is related to longevity in a population noted for its short height and great longevity. This research supplements a number of previous studies on the relationship between height and longevity.

Before examining the results of the study, it should be pointed out that a general secular increase in the mean height of populations in developed countries has been measured over the past 150 years (Olivier et al. 1977; Facchini and Gualdi-Russo 1982). This height increase is mainly attributed to improvements in living and nutritional conditions, as well as growing heterozygosis (Wolanski 1980; Terrenato and Ulizzi 1983). Therefore, height

The work of Luisa Salaris was supported by the operating program of the Autonomous Region of Sardinia (PO FSE 2007–2013) according to the LR 7/2007 for the “Promozione della ricerca scientifica e dell’innovazione tecnologica in Sardegna” [Promotion of Scientific Research and Technological Innovation in Sardinia].

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has often been considered an indicator of individual nutritional status (Fogel 1993; Alter, Neven, and Oris 2004; Johansson 2004).

A number of studies have reinforced the idea that taller people are healthier and less prone to cardiovascular diseases (Fogel 1994; McCarron et al. 2002; Morris et al. 2003). However, in a review of existing research, Samaras and Elrick (1999) have pointed out that more studies have found a negative correlation between height and longevity than have found a positive link.

Smaller individuals have lower death rates, since increased body mass favors faster aging (Samaras 1974; Sunder 2005). This relationship holds for both humans (Samaras and Elrick 2003; Samaras and Elrick 2003; Krakauer et al. 2004) and animals such as mice and dogs (Bartke 2000; Li et al. 1996; Miller and Austad 2006). However, this negative correlation is not always direct and clear. For human beings, the relationship is complicated by confounding effects of individual socioeconomic status, which then influence other factors such as nutrition and lifestyle (Castelli 1989; Lantz et al. 1998). Furthermore, especially for younger age groups, incidences of accidental death prevent a clear relationship from being established. Thus, the relationship between these two variables is not direct, and being shorter does not automatically mean that an individual will experience a longer life. However, shorter individuals appear to have the potential for greater longevity, which must be compatible with the quality of their nutrition, lifestyle, and environment (Samaras, Elrick, and Storms 2003).

We used data on conscripts from the municipality of Villagrande Strisaili, a village located in the Blue Zone longevity area of Sardinia, to investigate the relationship between height and longevity. The conscripts were born between 1866 and 1915. Individual data from the military registers were linked to data from the municipal civil registers. We then performed an analysis that examined life expectancy estimates for defined height groups and survival at the individual level.

The analysis first considered aggregate data by using life tables. This approach investigated the differential longevity of conscripts at older ages through the comparison of age-specific mortality rates and life expectancy estimates at different life points of advanced ages. Second, we addressed the individual level using Cox proportional hazard models, which allowed us to estimate the effect of height on the mortality hazard rate. To account for secular trends, the model controlled for birth cohort effects.

Materials and Methods

This study analyzed the data of Villagrande Strisaili newborns. Villagrande Strisaili is a village located in an inland area of Sardinia in the province of Ogliastra. More important, Villagrande Strisaili is one of 14 municipalities identified in Sardinia's Blue Zone longevity area (Poulain et al. 2004). Within the Blue Zone, this municipality recorded the highest value of the Extreme Longevity Index (ELI), which measures the proportion of individuals born between 1880 and 1900 who became centenarians (Poulain et al. 2004). In this study, individual data on newborns in this village were used to investigate the relationship between height and survival at older ages (70 or more years) and estimate the effect of height on survival in the long term. The threshold of 70 years was chosen according to findings from a prior investigation of Villagrande Strisaili data that showed that the relationship between the two variables emerges more clearly after this age (Salaris et al. 2006).

Adult height for each conscript born in Villagrande Strisaili between 1866 and 1915 was obtained from military registers ($N = 685$). In Italy, military service was compulsory for all men born between the years 1861 and 1985. All conscripts underwent a medical examination in which their heights were measured. Therefore, all height measurements used in this study are based on a conscript's height at 19 or 20 years old. Individual files in the military register show each conscript's enrollment number, name, surname, father and mother's Christian name, date of birth, height, and thoracic circumference.

Individual data on survival were gathered from the Villagrande Longevity Database (VILD; Salaris 2009), which provides survival data through September 2006 for 95 percent of the newborns included in the database. During the period considered—1866 to 1915—a total of 2,704 births were recorded in the village, with 1,384 being boys and 1,380 girls. Of the 1,384 boys born in Villagrande Strisaili between 1866 and 1915, slightly more than one-third died before reaching the age of 18, resulting in 930 adult survivors. Of these 930 survivors, 492 (35.5 percent) reached the age of 70. The birth cohorts under study were largely extinct in 2006. However, to include enough cases in the last age group and control for the presence of surviving conscripts, we cut off observation at 90 years. This choice enhanced the stability of the results and diminished the risk of bias resulting from the small size of the last age group.

Individual linkages were performed manually to avoid inconsistencies resulting from local usages of names given to children and spelling errors (Salaris 2009). The precise information on name, date of birth, and parents' names reported in each individual's military file facilitated this procedure. For 391 of the 492 septuagenarians, height measurements taken at age 20 were successfully linked to the individuals' survival after 70 years of age, reaching a linkage coverage level of nearly 80 percent.

We also checked the representativeness of the population. First, we compared survival estimates for all septuagenarians present in the VILD (492 persons) and estimates for the successfully linked septuagenarian conscripts (391 newborns). Differential survival was tested for significance, revealing that the two groups of septuagenarians had similar survival curves and differences were not statistically significant (log rank test chi square = 0.001, $p = .972$; Breslow generalized Wilcoxon test chi square = 0.005, $p = .942$).

Survival analysis was used to investigate differential longevity among defined groups of conscripts according to their height at military induction. Age-specific mortality rates and life expectancy estimates at different life points of advanced ages were compared. We used the Cox proportional hazard model to estimate the effect of height (continuous variable) on conscript survival. To control for the effect of secular trends, we included the decennial birth cohort as a control variable in the model. Analysis was performed using the statistical package SPSS 14.0.

Results

The average height for all male recruits in Villagrande Strisaili between 1866 and 1915 was 160.02 cm. When we compare this value to findings from previous reports on the Sardinian population in the same period (Coletti 1908; Piras et al. 2006; Arcaleni 2006), it is clear that the conscripts born in Villagrande Strisaili were slightly shorter than average Sardinian recruits (161.9 cm), who were themselves shorter than the national average (164.5 cm). In general, it has been observed that Sardinian conscripts were on average shorter than their national peers (Sanna 2002). Sanna further comments that regional differences in mean height value are the outcome of several factors that act at both the genetic and phenotypic levels and are related to initial genetic differences among Italian populations, as well as to differences resulting from socioeconomic and demographic conditions.

A preliminary investigation of the data on Villagrande Strisaili septuagenarian conscripts performed using linear correlation indicated an inverse association between military height at 20 years and age at death (Salaris et al. 2006). However, despite being statistically significant, the coefficient was weak ($r = -.158$, $p = .001$). The correlation coefficient was able to explain less than 3 percent of the variability of the two variables ($R^2 = .025$).

To further investigate the relationship between individual height and survival after 70 years, we looked at differences in life expectancy estimates for defined height groups at the individual level. The aim was to answer three related questions: Do survival estimates for short and tall individuals differ? Do shorter individuals live longer than taller ones? What is the effect of increases in height on conscript survival?

Villagrande Strisaili septuagenarian conscripts were grouped according to the Cacciari height classification (Cacciari et al. 2002), which outlines growth charts for height, weight, and body mass index (BMI) that are applicable to the whole Italian population aged 6 to 20 years. This classification includes four height groups: <161.1 cm, 161.1–173.7 cm, 173.8–186.2 cm, and >186.3 cm. After classifying all conscripts in the sample and carrying out a frequency distribution (see Table 1), we found no records of individuals taller than 186.3 cm and only two conscripts with a height value in the third category of 173.8–186.2 cm. As a result, two major groups emerged that were used to simplify the results of descriptive analysis: the Short group, consisting of conscripts shorter than 161.1 cm, and the Tall group, consisting of conscripts equal to or taller than 161.1 cm.

Table 1 also reports conscripts' mean height and mean age at death by birth cohort. According to the figures reported, there appears not to have been a marked secular increase in either height or survival in Villagrande Strisaili over the period examined. For 1896–1905 and 1906–1915 birth cohorts, we observed a slight decrease in mean height value. This drop is probably due to the effect of general living and nutritional conditions at the time, which could have worsened as a result of the smallpox epidemic that occurred in the village in 1895 and the intrusions of World War I and Spanish flu in the period 1915–1918 and subsequent years (Salaris 2009). However, to avoid a possible secular trend

Table 1

Villagrande Strisaili septuagenarian conscripts by birth cohort and height group

	Conscripts by height (cm)						
Birth cohort	< 161.1	161.1–173.7	173.8–186.2	> 186.3	Cases (*n*)	Mean height (cm)	Mean age at death
1866–1875	13	18	—	—	31	162.0	80.2
1876–1885	38	22	—	—	60	160.8	85.8
1886–1895	49	33	1	—	83	160.4	86.2
1896–1905	66	26	—	—	92	158.8	83.9
1906–1915	77	47	1	—	125	159.8	84.7
Total	243	146	2	—	391	160.0	84.6
Percent	62.2	37.3	0.5	—	100.0		
Mean height (cm)	156.7	165.4	n.a.	—	160.0		
SD	2.9	3.1	n.a.	—	5.14		
Mean age at death	85.4	83.5	n.a.	—	84.6		
SD	7.7	7.4	n.a.	—	7.6		
Final grouping	SHORT	TALL	TALL	—	2 groups		

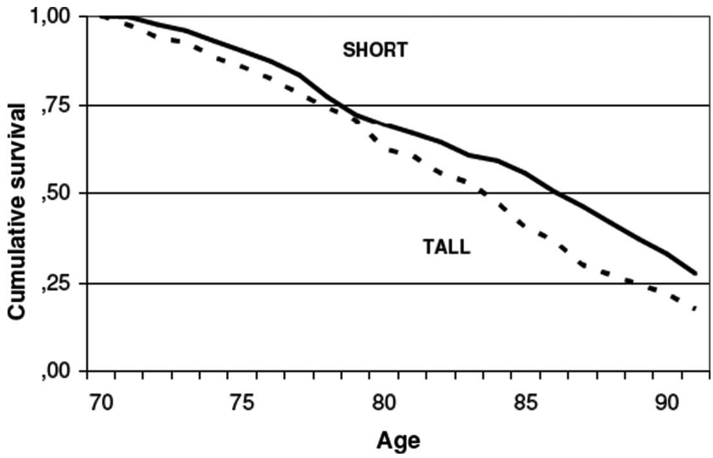

Figure 1. Comparison of survival estimates between Tall and Short septuagenarian conscripts in Villagrande Strisaili.

Table 2
Life expectancy estimates at different ages of septuagenarian conscripts in Villagrande Strisaili

		Life expectancy			
Age	Cases (*n*)	All conscripts	SHORT	TALL	Differences (Short – Tall)
70	391	14.6	15.4	13.3	2.1
75	345	11.2	11.8	10.2	1.6
80	260	9.0	9.6	7.9	1.7
85	193	6.2	6.4	5.7	0.7
90	111	3.9	4.1	3.6	0.5

effect, the results of the Cox proportional hazard model included birth cohort as a control variable.

Life table estimates were calculated for the two groups and survival curves compared, as shown in Figure 1. Differences between the curves were statistically significant starting from 79 years of age (log rank test chi square = 6.60, $p = .010$; Breslow generalized Wilcoxon test chi square = 7.01, $p = .008$). These differences in survival implied differential life expectancies (Ex). At age 70, tall ($\geq$161.cm) conscripts were expected to live two years less than their shorter peers (Table 2).

According to the data reported in Table 2, the probability for a 70-year old Villagrande Strisaili conscript to celebrate his ninetieth birthday was particularly high. Life table estimates for the Italian 1872–1915 birth cohort and data from the period life table for Sardinian males in 1974 show that on average, 10 to 11 percent of septuagenarians reached 90 years old. Among Villagrande Strisaili conscripts, this proportion was more than twice as high at 28 percent. This result underlines the fact that we are dealing with a population in which males enjoy an unusually high life expectancy. One recent study has compared

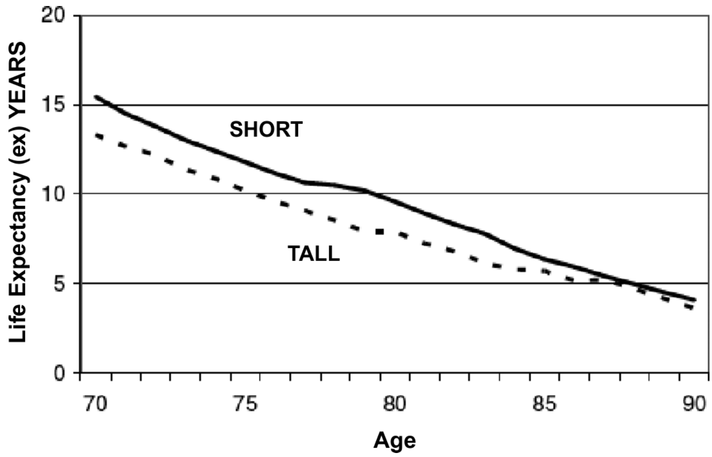

Figure 2. Life expectancy for Tall and Short conscripts by single year of age.

survival estimates for the Villagrande Strisaili population to estimates for the Italian population as a whole and has found that mortality trajectories of men and of women in Villagrande Strisaili show no gender gap, highlighting the exceptional survival rate of men in the village (Poulain, Pes, and Salaris 2011).

If we examine life expectancy estimates graphically, it seems evident that at more advanced ages, tall conscripts had similar survival rates. This change in life expectancy estimates can be explained in terms of reduced risk of death after age 85 (Figure 2). Starting at age 85, tall and short conscripts recorded similar life expectancy estimates. This convergence in mortality estimates could indicate a mortality crossover in survival estimates. Differences between population subgroups rarely stay constant across the life course; rather, they tend to produce a mortality crossover (Liu et al. 2008). The locus of intersection corresponds to the initial advantaged population's shift from a relatively low to a relatively high mortality, as determined by mortality acceleration and selection process (Hirsch, Liu, and Witten 2000).

Data analysis at the individual level confirms that height affects survival at the oldest of old ages. The estimates of the Cox proportional hazard model are presented in Table 3.

Initially, the model considered the effect of height (as a continuous variable) on survival after age 70, as well as the effect of birth cohort (Model 1). Among Villagrande Strisaili conscripts, height increases significantly reduced the probability of survival at older ages. Significant differences were also detected between conscripts by birth cohort. Accordingly, a second model investigated the relationship between height and survival, controlling for birth cohort. Results are reported in Table 3. The effect of height on survival was confirmed and, when free from the secular trend effect, proved to exert a more significant effect on survival than was estimated in the prior model.

Discussion

Taller height is often used as an indicator of health and nutritional status. However, this connection is not necessarily causal. Modern nutritionists recognize that excessive food intake damages health, and it is obvious that we eat too much based on our rapid growth,

Table 3
Cox proportional hazard estimates of survival of Villagrande Strisaili conscripts 70+

Variable	Coefficient	exp(coef)	*SE*	*z*	*p*
Model 1					
Height (continuous)	0.0306	1.03	0.0109	2.802	.005
Birth cohort					
1866–1875 (ref.)	0	1.00			
1876–1885	−0.4321	0.65	0.1133	−3.814	.000
1886–1895	−0.1723	0.84	0.0533	−3.230	.001
1896–1905	−0.0151	0.99	0.0338	−0.447	.650
1906–1915	−0.0397	0.96	0.0238	−1.669	.095
Model 2					
Height (continuous)	0.0342	1.03	0.011	3.1	.002

early sexual maturation, obesity, and maximal height attainment (Giovannucci et al., 2004). In addition, nutrition experts view processed foods as harmful, because their high levels of salt, calories, protein, and saturated fat promote increased body size (Samaras 2010). One in-depth study of health and nutrition found that populations living before the industrial revolution were shorter and lighter than today's population and chronic diseases were rare compared to the twentieth century (World Cancer Research Fund and the American Institute for Cancer Research 2007).

Adequate nutrition is important for good health, but nutritional scientists were often misguided in promoting animal protein and processed food during the nineteenth and twentieth centuries (Popkin 2009:29). One comprehensive review of the scientific literature concluded that a global shift toward urban living and industrialization resulted in greater height and weight and paralleled the increase in chronic diseases (World Cancer Research Fund and the American Institute for Cancer Research 2007).

Certainly, malnutrition and childhood diseases stunt growth and have long-term health disadvantages. However, abundant research shows that many short populations that follow traditional diets are often free of Western diseases. For example, although Okinawans eat less and are smaller than mainland Japanese, they remain active into old age, have lower incidences of heart disease and cancer, live longer, and have a higher percentage of centenarians (Kagawa 1978). Thus, in the absence of malnutrition, childhood disease, and poor medical care, shortness does not appear to be harmful to health.

Biologists appear to be convinced that small body size correlates with greater longevity (Gavrilova and Gavrilov 2008). However, a number of historical demographers have found that small bodies have reduced longevity and taller people have lower all-cause mortality (Waaler 1983; Fogel 1994). For example, Waaler (1983) shows that the mortality risk of shorter people is higher up to 70 years of age in Norway than the risk of taller people. However, Waaler also shows that for men above six feet (over 183 cm), male mortality increases substantially between 70 and 85 years of age. Since most people within a birth cohort die after 70 years of age, this finding challenges the thesis that taller people are healthier.

The findings and duration of our study are similar to those found by Holzenberger et al. (1991). Holzenberger's study tracked 1.3 million Spanish military recruits over a 70-year period and found that shorter recruits lived longer ($r = -0.6$, $p < .001$). Krakauer et al.

(2004) also found that shorter Swedes had a greater longevity compared to taller ones ($r = -0.26$, $p = .006$), and Samaras (2009a) calculated the average loss of life with increasing height to be 0.52 yr/cm. Samaras (2009b) also found that the top six developed countries had populations that enjoyed superior life expectancy and were substantially shorter than the populations of the six tallest countries. The six shortest countries had on average the third highest life expectancy, compared to the six tallest countries' average ranking of 29. For the United States population, Samaras (2009a) found that white men were 9 percent taller than white women and had a 9 percent lower life expectancy. Men lost 0.52 yr/cm compared to women.

Although the Villagrande population studied here was rather short, other longevity studies have looked at a wide range of populations with varying heights, including baseball players, football players, and the general U.S. population, and have produced similar results (Samaras 2007a; Samaras and Elrick 1999). Thus, the finding that longevity decreases with increasing height for this short population is consistent with findings from studies of much taller populations.

In this study, men lost an average of 0.23 years for every extra centimeter of height at 70 years of age. Samaras (2009a) found an average loss of 0.52 yr/cm based on several other studies. The reason for this discrepancy may lie in the homogeneous nature of life and diet in Villagrande Strisaili. Furthermore, previous studies encompassed a greater range of heights ($\leq$163 cm to $\geq$193 cm, with most subjects being $>$ 170 cm). The height range in this study was more limited, with 243 men being $<$ 161.1 cm, 146 men being between 161.1 and 173.7 cm, and only two men being between 173.8 and 186.2 cm.

It should be noted that the correlation coefficients found in several previous studies vary from −.12 to −.86 (Samaras, unpublished data). The average for this range of coefficients was $r = -.34$ and the variance explained was about .12 ($R^2 = .34^2$). Thus, height represents only 12 percent of all factors that affect longevity. The coefficient for Villagrande Strisaili recruits was $r = -.158$ ($p = .001$), or only 3 percent. Eighty-eight per cent of longevity is thus due to genetics, socioeconomic factors, nutrition, BMI, weight, smoking, and physical activity. Substantial differences in these factors, such as weight, can also mask the impact of height on longevity. For example, an earlier study by Samaras, Storms, and Elrick (2002) found that longevity declined by 0.4 yr/kg as weight increased, without considering BMI or height. Differences in socioeconomic status can also increase mortality by up to 400 percent. It is interesting to note that in the developed world, more privileged socioeconomic groups are taller and have lower cardiovascular disease (CVD) mortality than less privileged groups. However, in developing countries, wealthier groups are taller, heavier, and have higher CVD mortality rates than shorter, leaner, poorer groups.

According to the data available for Villagrande Strisaili conscripts, there was a general increase in height and life expectancy over the 50-year period. However, the secular increase proved to be limited, and the Cox proportional hazard model controlling for the effect of decennial birth cohort showed that when individual data analysis was freed from the confounding effect of birth cohort, the effect of height on survival after 70 years remained significant.

Another potential confounder is relative weight between short and tall people (Samaras 2007b). Studies must take care to compare tall and short people of the same body proportions. If taller people are lean and short people are stocky (higher BMI), the longevity findings will tend to favor taller people, since each point increase in BMI raises CVD and all-cause mortality by about 10 percent. In developed populations, taller people tend to be leaner in comparison to shorter people, especially when upper-class people are compared to working-class people. However, one recent study (Cohen and Strum 2008) found that in the United States, taller people are getting fatter at a faster rate than shorter people. However, increased mortality of taller people as a result of greater weight may not be evident for many years.

Unfortunately, the impact of BMI on longevity could not be analyzed for this Villagrande Strisaili study, because the data files on recruits did not include weight or BMI.

Biological Explanations for Greater Longevity of Shorter People

The following section presents several biological mechanisms that could explain the greater longevity of shorter, smaller people. These mechanisms include caloric restriction, number of cells in the body, cell replication potential, telomere shortening, DNA damage, heart pumping efficiency, and biological biomarkers or parameters.

Caloric restriction. Caloric restriction (CR) provides the most consistent and impressive evidence for increasing longevity in mammals, including monkeys and humans. The initiation of CR during the growth period reduces height and weight and increases longevity in mammals. However, some studies have found that initiation of CR in adulthood also provides health benefits and reduced body size via lower body weight. For example, Mattson (2005) reports that reducing adult energy intake by 30 to 40 percent below ad libitum levels increases both the average and the maximum lifespan of mice and rats. This study demonstrated that mammals (including humans) subjected to CR experience beneficial reductions in blood pressure, glucose, insulin, insulin-like growth factor -1 (IGF-1), triglycerides, heart rate, atherosclerosis, and inflammation. Mattson also reports that CR drives desirable increases in high-density lipoprotein, insulin sensitivity, cognition, and pain threshold. Intermittent fasting produces similar results in most of these parameters. More recently, Fontana (2009) has found a number of similar health benefits for humans on CR.

Shorter bodies have fewer cells. Taller, bigger people have trillions more cells than do shorter people of the same body type. Because the higher number of cells allows greater exposure to free radicals and carcinogens, taller people have a greater risk of cancer. The World Cancer Research Fund and the American Institute of Cancer Research (2007) recently sponsored a five-year review of research findings and concluded that taller height was strongly and consistently related to increased cancer risk. Many other reports and reviews have found the same results (Samaras 2007a).

More potential cell replications over a lifetime. Somatic cells generally have a limited number of replications over a lifetime. When old age is reached replacement cells may no longer be available to repair damage to tissues and organs. Taller, larger bodies are thus at a disadvantage, because they use up more cells in the initial production of a bigger body and then in the daily replacement of billions of damaged or dead cells during the rest of the individual's life. This lower replication potential can ultimately reduce the functional capability of human organs. With the exception of the heart, lungs, and spleen, most organs are relatively smaller in taller bodies than their counterparts in smaller bodies. Thus, these organs can be damaged more severely with age, and their functional capability can be reduced as a result of the demands of their bigger bodies.

Maier, van Heemst, and Westendorp (2008) found that in old age, shorter bodies have longer telomeres compared to those present in taller bodies. Telomeres tie the ends of chromosome pairs together and shorten with each replication. Most studies indicate that longer telomeres are related to greater longevity and better health. Women have longer telomeres than men and generally live longer than men. However, at birth, men and women have the same length telomeres. Thus, it appears that the larger male body results in shorter telomeres and reduced longevity.

Lower DNA, cell, and tissue damage. Giovannelli et al. (2002) has found that taller people experience substantially more DNA damage than shorter people. Based on the data provided in that study, Samaras (2007c) calculated that a 19 percent increase in height increased DNA damage by 85 percent.

Under ad libitum diets, taller people are subjected to greater numbers of the free radicals produced by normal metabolism, because their metabolism is greater than that of shorter people with similar lifestyles (Samaras 2007c; Samaras 2009b). Free radicals damage body cells, tissues, and organs and thus promote illness and reduce longevity. In similar environments, taller people also eat more and are thus exposed to more natural and man-made toxins, which increase free radicals. In addition, greater food and liquid consumption increases the intake of bacteria, viruses, and parasites. While this risk may be low over the short term, a life-long exposure may have an impact on longevity.

Greater heart-pumping efficiency. Taller people have greater left ventricular mass (LVM), which has been correlated with increased risk of CVD, all-cause mortality, and sudden death (Rodrigues, Pimentel, and Mill 2007). LVM also becomes less efficient as body size increases. De Simone et al. (1997) has reported that the pumping efficiency of the left ventricle decreases in proportion to heart mass, with the heart pumping a smaller percentage of its chamber blood per stroke as body height and size increase (heart size correlates with body size). This finding has been supported by studies showing that many populations of short men ($\leq$163 cm) are free of coronary heart disease and stroke (Samaras 2007a; Samaras 2009b). No tall ($\geq$178 cm) Western populations have been found to have the same experience. Taller people also tend to have higher rates of atrial fibrillation, a risk factor for CVD (Hanna et al. 2006).

Desirable levels of biochemical biomarkers. For smaller bodies, the levels of a number of biochemical biomarkers experience beneficial changes compared to taller bodies of the same proportions. For example, C-reactive protein, blood pressure, and total cholesterol tend to be lower and high-density lipoprotein higher in shorter people. Insulin and IGF-1 also increase with body size, which can promote cancer and reduce longevity. However, lower protein intake also appears to reduce IGF-1 levels (Fontana et al. 2009). Shorter people have higher levels of sex hormone binding globulin and lower levels of apolipoprotein B, which reduces the risk of CVD, cancer, and all-cause mortality (Samaras 2007c).

Rapid growth reduces longevity. High-protein and high-energy diets promote rapid growth and height. However, rapidly growing individuals tend to experience reduced longevity compared to slower growing individuals (Mangel and Munch 2005). Rollo (2007) has reported that “slow and protracted juvenile growth” could produce large increases in longevity.

Conclusion

In conclusion, shorter people and taller people exhibit differences in longevity. Although a tall body generally reflects abundant nutrition and good living conditions during the growth period, this height has negative ramifications as well. Biological mechanisms indicate that a larger body places greater stress on cells, tissues, and organs, which can reduce longevity. The results of this study on Villagrande Strisaili conscripts represents an example of a population in which short individuals record better survival estimates at more advanced ages than do taller individuals. The analysis shows that at age 70, short conscripts have a life expectancy that is two years higher than that of their taller peers. It is clear from earlier Sardinian research and studies from other parts of the world that shorter height is more likely to promote longevity when a population is exposed to a life-long healthful diet and lifestyle.

Future investigation should improve life table estimates while taking into account heterogeneity. Every population includes subgroups that are characterized by different mortality risks (e.g., frail and robust individuals), but life table estimates simplify the estimation to an average and are not able to capture differences, producing bias as a result of both the selection process and the changing composition of the population at risk.

Further studies examining nutrition and anthropometry are recommended among long-living populations such as those of Okinawa, Japan; Ikaria, Greece; Nicoya, Costa Rica; and Seventh-Day Adventists in Loma Linda, California, United States, to identify the factors that promote longevity.

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