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Do taller people live longer? Evaluating the relationship between adult stature and longevity

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Abstract

Body height is positively correlated with overall health and survival. Previous studies have found that taller people are healthier and live longer than their smaller counterparts. Despite numerous investigations, the correlation between adult stature and longevity remains uncertain. The objective of the present study is to evaluate the relationship between adult height and lifespan. Data were available from 480493 men and 364666 women who died in the years 2004-2008 in Poland. Pearson's r coefficients of correlation were calculated and ANOVA was employed. The correlation between height and longevity was negative and statistically significant in men ($r = -0.27$, $p < 0.0001$) and women ($r = -0.25$, $p < 0.0001$). However, after allowing for the cohort effect, these correlations proved to be very weak and significant. On balance, these results do not corroborate the hypothesis that taller people live longer, and the effects of body height on survival were small. In this article, these findings are discussed in an attempt to identify the biological mechanisms that are responsible for greater longevity in short people. This paper also deals with several biological factors and mechanisms involved in the link between body size and longevity.

Running title: Adult stature and longevity in Poland

Keywords: age, body height, stature, lifespan, longevity, survival

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Introduction

Animal studies have shown that apart from predicting longevity, body size also predicts extrinsic and intrinsic mortality. In humans, body height is one of the most conspicuous morphological traits that has very important social and ecological consequences [1,2]. For a long time, researchers have been trying to ascertain whether tallness reflects better biological quality. Earlier epidemiological studies have indicated that shorter stature is associated with poor nutrition during childhood, lower socioeconomic status (SES) as well as increased morbidity and mortality.

Human body height is positively correlated with SES, social mobility [3,4], physical attractiveness and reproductive success in men in Western societies [5], emolument [6], physical health and survival [7-11]. In fact, multiple investigations have convincingly shown that adult stature correlates positively with overall health and survival. Anthropologists, demographers and economists often use stature as an indicator of the health status and disease exposure of human populations and as such an indicator taller height correlates with longer life.

However, the results are mixed regarding the relationship between adult height and longevity as this interrelationship becomes tenuous when certain confounding factors, such as body mass index (BMI), body fat percentage (BFP) and SES, are allowed for. Therefore, it is currently controversial whether taller stature is linked to higher biological quality and better survival, all the more so as recent studies have challenged this long-standing interpretation. In general, body height and cardiovascular disease (CVD) mortality are inversely correlated [11]. Nevertheless, not all authors agree that shorter people are more vulnerable to CVD because individuals of similar body proportions, BMI and BFP should be compared with each other [12].

On the other hand, many studies have revealed that taller people are healthier and tend to live longer [3,7,11,13,14]. The hypothesis that taller individuals have a longevity advantage is widespread, and these early studies have long been interpreted as indicating that taller people have lower mortality rates throughout their ontogeny. Nevertheless, the relationship between adult stature and longevity, which has recently been studied more intensively, remains unclear. Interestingly, recent data suggest that greater body size is generally costly in terms of longevity and smaller individuals who maintain a healthy lifestyle tend to live longer than their larger counterparts. This phenomenon occurs in human and nonhuman species [15-18]. The purpose of this study is to explore the relationship between adult height and longevity in the Polish population.

Materials and methods

The study sample was obtained from two electronic databases at the Ministry of Internal Affairs and Administration in Warsaw, Poland, i.e. the Universal Electronic System for Registration of the Population (sex, dates of birth and death), and from the State Register of Identity Cards (declared body height), and concerned adult deaths in the years 2004–2008 in Poland. To evaluate the relationship between stature and longevity in the Polish population, data on adult height and exact dates of birth and death from 845159 individuals, including 480493 men and 364666 women, were analyzed.

The collected data have several important advantages. First, the sample is very large and representative for the population, which is of paramount importance. It is often argued that gathering a very large sample of material representative for the whole population is a *sine qua non* prerequisite in such investigations. This is necessary because height is a trait that is determined by many biological and social factors, while the variation in lifespan and body size is very large in each population. Moreover, there are numerous defined and unknown selection factors.

The next important characteristics of the study sample are heterogeneity and typical causes of death. Many epidemiological and anthropological studies are based on statistics from small geographical areas, e.g. a given city or district, where the residents are affected by various local factors, obtained in a short time, or concerning individuals who died of a specific disease, which is justified for practical reasons but can negatively affect the validity of research conclusions.

Another advantage of the analyzed material is the high reliability of data on dates of birth and death, certified by relevant documents. The use of declared body height is acceptable, in a situation when measurements cannot be obtained. Among adults, there is a high and significant correlation between the declared and measured values of stature. Although it is true that respondents often overestimate their stature, these effects are robust and significant when people advertise for dating, and not when they provide information on their stature for legal purposes [19,20].

The normality of the data distribution was tested with the goodness-of-fit test for a normal distribution. Regression analysis, correlation analysis and one-way ANOVA were performed. The cohort effect was eliminated by transforming the actual height into the theoretical height that a given individual would have if he or she was born in the same period in the youngest birth cohort. All statistical analyses were conducted using Statistica software, version 9.0, StatSoft.

Results

Adult height and lifespan were normally distributed. Men were taller than women (171.6 ± 6.6 cm versus 159.6 ± 6.2 cm; $F = 1.14$; $p < 0.0001$) and lived significantly shorter (67.9 ± 13.8 years versus 75.0 ± 12.7 years; $F = 1.19$; $p < 0.0001$).

The initial analysis revealed a significant inverse relationship between height and longevity in men ($r = -0.27$, $p < 0.0001$) (**Fig. 1**) and women ($r = -0.25$, $p < 0.0001$ (**Fig. 2**).

However, after controlling for the cohort effect, this interrelationship proved to be very weak in men (**Fig. 3**) and inverted U-shaped in women (**Fig. 4**). Thus, although shorter people lived longer than their taller counterparts, the relationship between adult stature and longevity turned out to be tenuous. Thus, body height was not a useful predictor of longevity.

Discussion

In accordance with the traditional views, taller stature is a superior configuration in terms of health and survival as shorter height is associated with lower biological condition due to congenital diseases, immunity disorders, infections, inadequate nutrition, low SES and various health problems. Numerous studies have investigated the interrelationship between body size and overall survival [3,7,8,11,13,14,21-24]. The results of the current research indicate that taller men do not live significantly longer than their shorter counterparts, which is in agreement with several previous studies [12,21-26,27,28].

Given that taller people have better nutrition and higher SES, including income [4-11], these findings convincingly demonstrate that greater height is not associated with enhanced longevity in the studied population. Contrary to popular belief, these results show that taller people do not live longer than their shorter counterparts. However, there are both theoretical and empirical reasons for doubting that the observed relationship between stature and longevity is direct and causal.

It has been established that adult height represents the interactive effects of many processes [29], including the influences of genetic, epigenetic, nutritional, psychological, ecological and life-style-related factors such as pathogens, parasites, stress level, amount of sleep, diseases or disorders. It should be remembered that not only environmental and life-style relate factors, such as an unhealthy

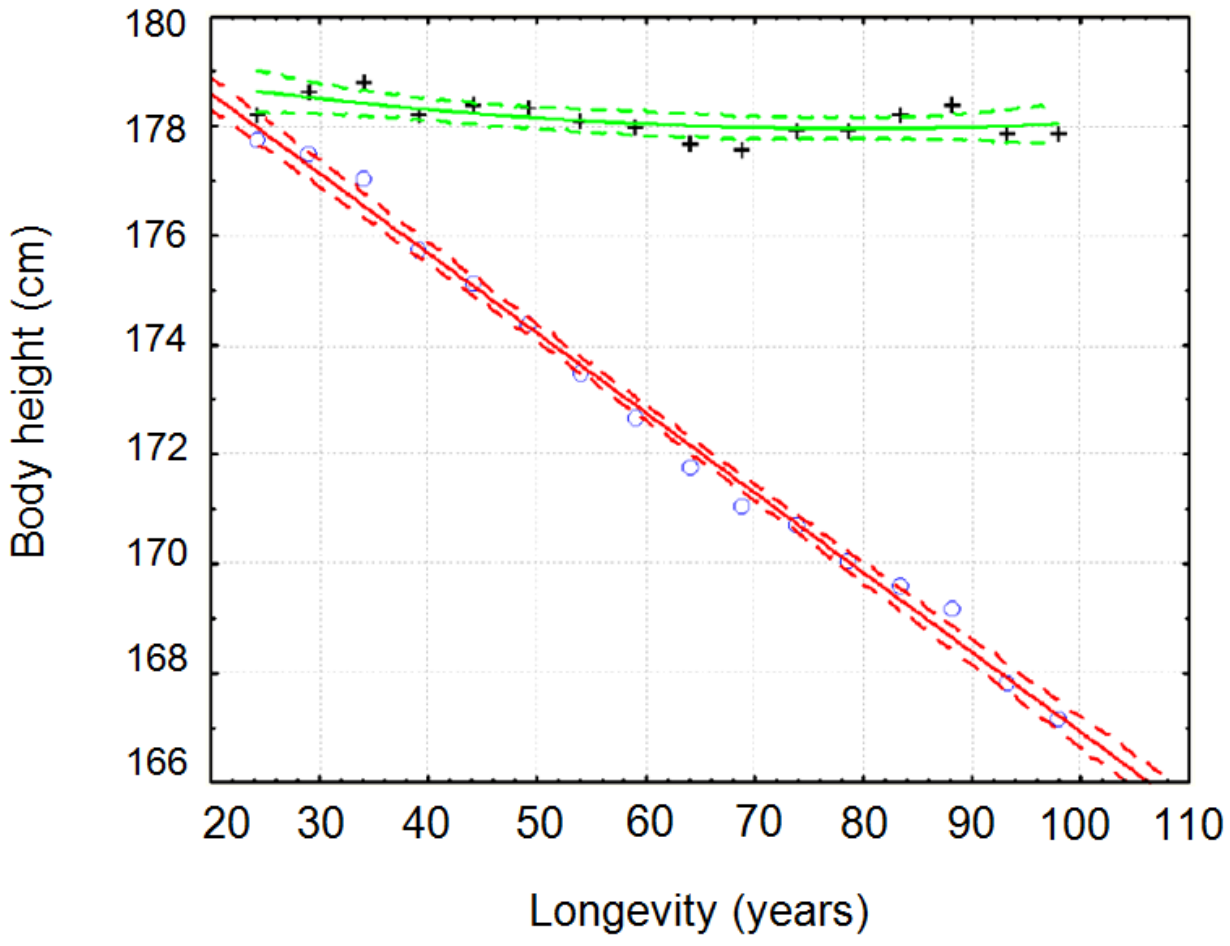

FIGURE 1 The relationship ± 95% confidence interval between the actual height and longevity (red line) and the theoretical height and longevity (green line) in men (N=480493)

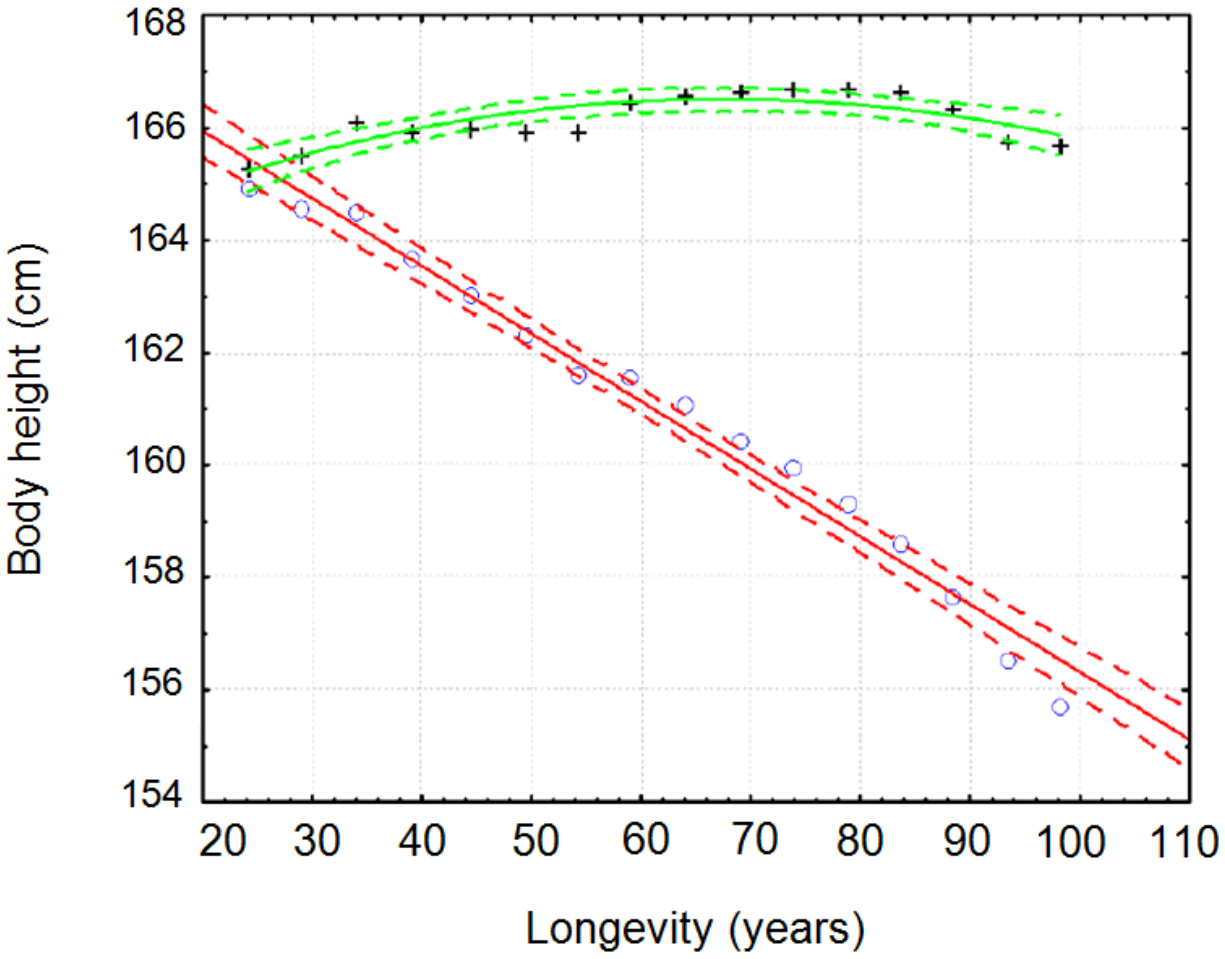

FIGURE 2 The relationship ± 95% confidence interval between the actual height and longevity (red line) and the theoretical height and longevity (green line) in women (*N*=364666)

diet and malnutrition, but also genetic disorders, such as Down syndrome, Russel-Silver syndrome, Noonan syndrome, Turner syndrome, Prader-Willi syndrome, dwarfism due to achondroplasia and other causes, as well as metabolic and developmental problems, such as diabetes, Cushing's syndrome, growth hormone (GH) deficiencies, renal dysfunctions, heart failure etc., can result in short stature.

Interestingly, Beard and Blaser [29] argue that infectious diseases in childhood can negatively affect adult stature. Indeed, numerous studies have shown that children who suffered from diarrhea and dehydration were significantly shorter as adults than those children who did not have these problems. For example, a study by Martorell and associates [30] demonstrated that in Guatemala children relatively free from diarrhea during the first seven years of life would be around 4 cm taller than children more frequently ill with diarrhea. Interestingly, it has been estimated that each episode of diarrhea in childhood is associated with a decrease in adult height by roughly 0.6 cm [31]. Furthermore, several other studies confirm the hypothesis that infectious diseases in the first years of life are important factors affecting adult stature. Clinical observations suggest that other medical problems, such as chronic granulomatous disease (CGD), can also result in diminished final height.

Epidemiological and clinical studies have provided evidence that taller stature is linked to increased risk of cancer [27,28], even though it is unclear why taller people are more likely to develop cancer. However, a number of tentative explanations can be offered. For example, taller and stouter individuals have more somatic cells as opposed to their smaller counterparts. The total number of cells can predict the relationship between body size and cancer with no need to suggest additional factors [32].

Although cells are constantly repairing and maintaining themselves via the intake of energy from food, individuals within the same species that have a considerable amount of extracells are more prone to DNA damage and cancer. This is because more cells in the body increase the risk factor for DNA damage and somatic mutations. Furthermore, an organism that accumulates extra senescent cells, a situation that can occur in those organisms that produce more cells and need more new cells to

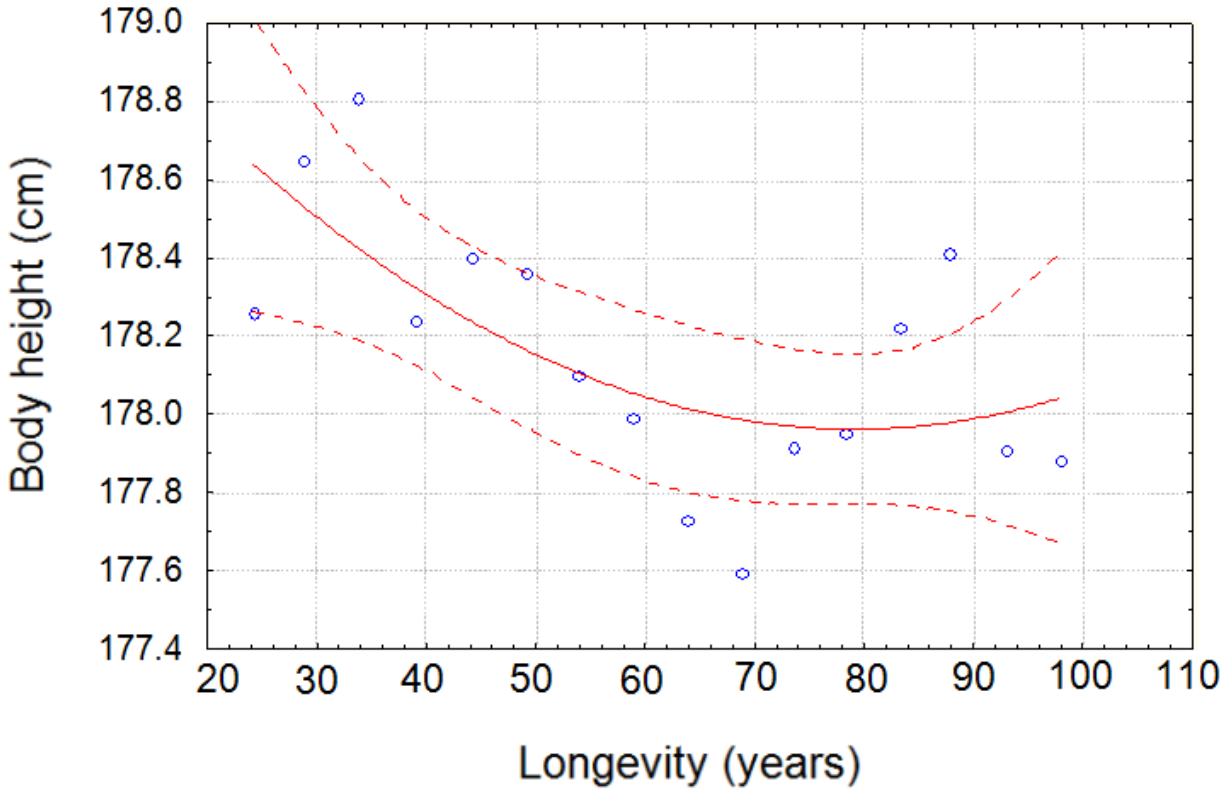

FIGURE 3 The relationship ± 95% confidence interval between the theoretical height and longevity in men (*N*=480493)

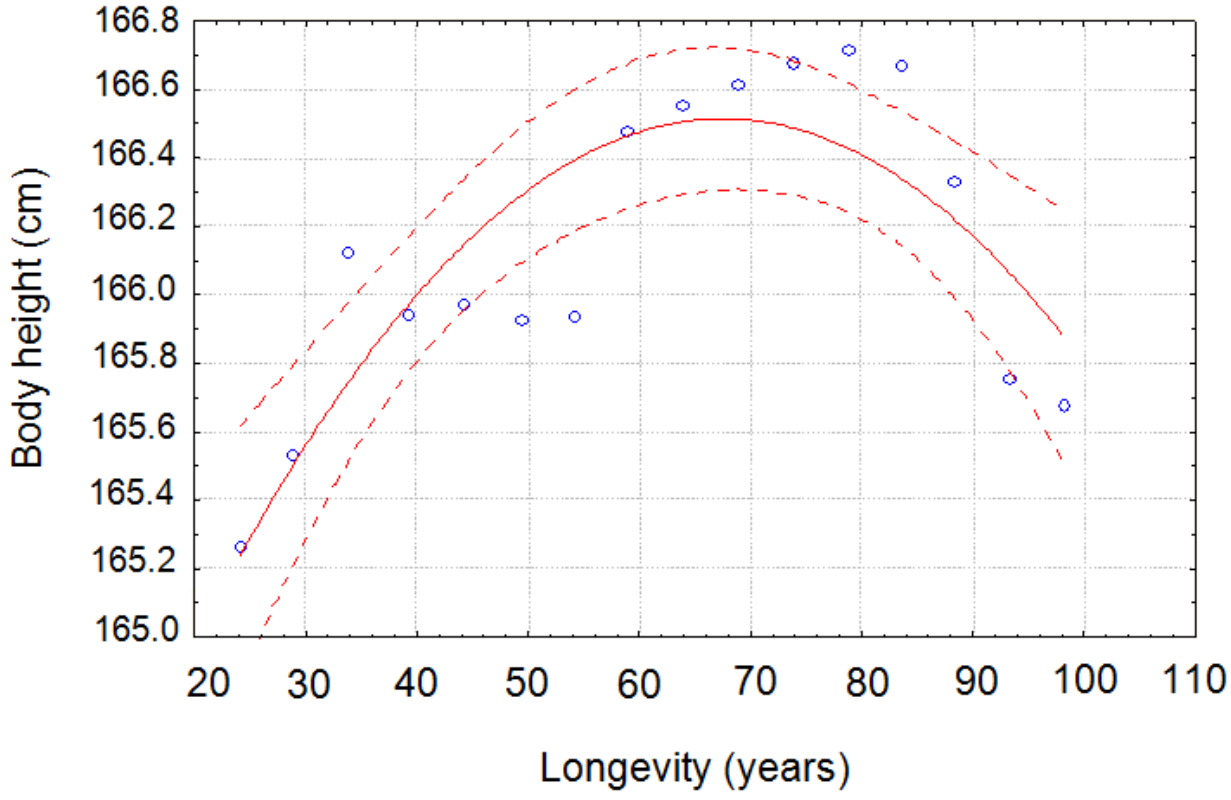

FIGURE 4 The relationship ± 95% confidence interval between the theoretical height and longevity in women (*N*=364666)

replace older ones, is more likely to reach higher levels of chronic low-grade systemic inflammation, which is detrimental to health and survival [33,34].

Moreover, it should be remembered that biological factors related to greater height, such as hormonal and genetic influences, can directly stimulate cancer development and progression. It has been established that growth is physiologically costly, and smaller individuals within mammalian species tend to have lower mortality rates. For example, dogs, cows, horses and mice have been studied for a long time, and smaller individuals live longer [15-18]. The data showing that smaller individuals outlive their larger counterparts suggest a role of biological factors and mechanisms (**Tab. 1**). Interestingly, animal studies indicate that caloric restriction (CR) reduces body size and simultaneously extends lifespan. Additionally, some studies have suggested that tall people are less likely to reach advanced ages [21,25,26,35].

In 2017, Pawlowski and associates [36] tested the hypothesis that adult stature indicates immune system quality. They recruited a group of Polish volunteers, including 96 healthy men and 97 healthy women, all aged 18.6 to 36.7 years. For all subjects, blood cell morphology with smear and biochemical tests were performed. Other biological factors, such as BMI, body fat percentage and hormonal profiles, were also evaluated. Their results do not confirm the positive relationship between adult height and immune response. However, the hypothesis that greater height indicates better immune quality in men cannot be discarded as not all immune components were tested. They concluded that there was no association between body height and all analyzed immune parameters.

It seems that the correlation between taller height and lower mortality is incidental to increased life expectancy [37]. According to several researchers, including Walker and Kaplan, in the Occident greater height is often related to overnutrition. Interestingly, when Osika compared taller and shorter people in the lower economic class, the taller had an almost 40% higher risk of heart attacks (Samaras, personal communication). This finding also suggests that higher economic status protects taller people from chronic diseases and premature death.

According to Samaras [12], who studied various human populations and ethnic groups, within a population of deceased American veterans, the shorter individuals lived longer. Interestingly, native Americans showed a substantial increasing trend in CVD and all-cause mortality with increasing height. This eminent researcher also reported that within the following homogeneous groups, the shorter people lived longer. These groups included: baseball players, high achievers, entertainers, boxers and strong men. Salaris and associates [25] reported that within an isolated village in Sardinia, shorter men lived about 2 years longer than their taller counterparts.

He and colleagues [26] investigated a population of over 8000 Japanese Hawaiian elderly males and these researchers reported that shorter men had lower mortality rates. In addition, Wilhelmsen and

TABLE 1 Biological advantages related to shorter and taller height

BENEFITS OF SHORTER HEIGHT	BENEFITS OF TALLER HEIGHT
Smaller people have fewer cells. The total number of somatic cells predicts the relationship between adult height and cancer risk [32]	Larger people have lower oxygen uptake, heart rate and lower basal metabolic rate compared to smaller individuals [37]
Short and slim people eat less. Low food energy intake has certain health benefits, e.g. lower intake of toxins, pesticides, antibiotics and hormones, the positive effects of mild caloric restriction (CR) on lifespan	Taller stature may reflect biological quality and can be related to better health, nutrition and higher SES, including income and educational attainment [3,4,7,13,36]
Smaller individuals have reduced GH/insulin/IGF-1 signaling and less active mTOR (mammalian/mechanistic target of rapamycin), which may confer longevity benefits [15-18]	Short individuals may have smaller-sized coronary arteries which might be earlier occluded by atherosclerosis. Several meta-analyses have shown that tall people are less susceptible to CVD [11]
Shorter telomeres are a risk factor of cancer, and shorter nonagenarians tend to have longer telomeres [35]	Taller and larger individuals are less vulnerable to dehydration as opposed to their smaller counterparts [37]
Shorter people have faster reaction times, greater stability, endurance and reduced back problems. Hip fractures are also more common in taller people [37]	Taller individuals are stronger and run faster than their shorter counterparts. Tall people have better jumping ability and are better swimmers [37]
Short women have greater reproductive success than tall women [2]	Tall men have greater reproductive success than short men [5]

collaborators [21] tracked a group of 67-year old Swedish men to 90 years of age. They concluded that individuals who were shorter at baseline were more likely to reach 90 years of age compared to taller men. These subjects were Swedish males living in the same city and born in the same year.

Steven Austad argues that Samaras reaches his conclusion by comparing heights of different groups of people, e.g. different sexes or ethnic groups, within a given country. Austad maintains that due to variation in hormonal milieu, diet, lifestyle and multiple other factors, it is extremely difficult to evaluate the claim that smaller people live longer in the face of a mountain of opposing epidemiological evidence. Nonetheless, one can argue that this mountain of opposing data is based on mortality studies that did not track the entire cohorts up to advanced ages and until death.

This study has limitations that should be acknowledged. First, declared height was used. Second, the analysis did not consider potentially significant confounding factors, such as BMI and SES, because these data were unavailable. However, the link between height and longevity can be established based on the study sample used for the analysis. Since taller men score better in terms of SES, the finding that they do not live significantly longer than their shorter counterparts is interesting and intriguing.

Conclusions

In both sexes, adult height and longevity were inversely correlated. After allowing for the cohort effect, the interrelationship between these two life history parameters proved to be very weak and linear in men and inverted and U-shaped in women. In general, these results do not comport with the traditional belief that taller men are healthier and live longer. Nevertheless, the effects of stature on lifespan were small, thereby suggesting that body height is not a useful predictor of longevity.

Ethical approval

The conducted research is not related to either human or animal use.

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Conflicts of interest

The authors declare they have no conflict of interest.

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