


# The association between body height and longevity: evidence from a national population sample

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**Background:** A wealth of research suggests that taller individuals are healthier and live longer than their shorter counterparts, although conflicting results have been reported. This study aims to investigate whether taller individuals in Poland exhibit greater longevity compared to their shorter counterparts.

**Materials and methods:** Data on declared height were collected from 848,860 adults who died in the years 2004–2008 in Poland. To eliminate the cohort effects, Z-values were computed. Pearson's correlation coefficients were calculated independently for males and females. Subsequently, one way ANOVA was performed.

**Results:** The correlation between adult height and longevity was negative and statistically significant in both men and women. After eliminating the effects of secular trends in height, the correlation was very weak ( $r = -0.0044$  in men and  $r = -0.0038$  in women) but significant ( $p = 0.023$  and  $p = 0.022$ , respectively).

**Conclusions:** Despite the significant correlation observed between the two variables, it should be noted that the relationship between height and longevity is very weak and tenuous. Overall, these results do not support the hypothesis that taller individuals have a longevity advantage. Further research is warranted to identify the underlying biological mechanisms driving this phenomenon as well as to explore additional variables affecting human longevity. (Folia Morphol 2024; 83, 1: 139–145)

**Keywords:** adult height, body height, lifespan, longevity, stature, survival

## INTRODUCTION

Human body height is a polygenic trait that is controlled by several genomic loci [35]. Stature is also one of the most conspicuous morphological traits that has important ecological and social consequences [17]. Historically, taller individuals were more privileged as they were the richest people who had significantly more resources to address own demands

and who were able to lead a healthy lifestyle [12]. An abundance of studies have reported that body height correlates positively with educational attainment, socioeconomic status (SES), income, wealth, reproductive success, overall health and survival [4, 19, 25–27]. However, these links are often complex and may be obscured by various interactions. For example, women prefer taller men but men prefer shorter

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women [25, 30, 31]. In general, body height and cardiovascular disease (CVD) mortality are inversely correlated [11]. Nonetheless, not all researchers agree that shorter people are more susceptible to CVD as individuals of similar body proportions, body mass index (BMI), educational attainment and SES should be compared with each other [29].

Several studies have revealed that taller people are healthier and have a longevity advantage over their shorter counterparts [11, 12, 15, 24, 26]. It is generally accepted that taller stature reflects better childhood nutrition and better environment and as such can be used as a genuine indicator of the health status and disease exposure in historical populations [11]. Furthermore, the hypothesis that taller individuals are healthier and live longer is widespread among physicians and anthropologists. This is because these early studies have long been interpreted as indicating that taller individuals have lower mortality rates and live longer. Nevertheless, the relationship between adult stature and longevity, which has recently been studied more intensively, remains unclear. For instance, compelling data from animal studies show that greater body size correlates with shorter lifespan within, but not between, mammalian species [1, 2, 6, 21]. Interestingly, recent findings indicate that greater body size, but especially body weight and BMI, is costly in terms of longevity, and smaller individuals outlive those that are larger. Moreover, a similar relationship has been shown in studies of various human populations [1, 2, 9, 13, 28, 29]. The aim of the current study is to explore the relationship between adult height and longevity in adults who died between 2004 and 2008 in Poland.

## MATERIAL AND METHODS

For the purpose of the study, we collected data on all adult deaths in the years 2004–2008 in Poland from the national archives at the Ministry of the Interior and Administration in Warsaw. In total, records from 848,860 individuals, including 483,512 (57%) men and 365,348 (43%) women, were available. These data derive from two sources: (1) signalments in the census obtained from identity card offices (body height declared on the identity card) and (2) the Universal Electronic System for Registration of the Population 'PESEL' (sex and dates of birth and death).

The collected data have a number of advantages. Firstly, the sample is very large and representative for

the whole population. It is generally agreed that the collection of large samples is a *sine qua non* prerequisite. Secondly, the study sample involves typical causes of death. Numerous studies were confined to the data that were derived from small geographic areas, e.g. a given city or district, obtained in a short period of time or from individuals who died of a specific disease, e.g. CVD or cancer. Although this approach is justified for practical reasons, this can be precarious. Our data are based on reliable documents, i.e. death certificates, which were issued by the authorities. Although it is true that respondents often overestimate their height, these effects are significant when people advertise for dating, and not when they provide information on their stature for legal or official purposes [16, 23]. Thus, it should be emphasised that the use of declared height instead of measured height is acceptable.

The normality of distribution was tested with the goodness-of-fit test  $\chi^2$  as well as coefficients of asymmetry (*As*) and kurtosis (*K*). Student's *t*-test and one-way analysis of variance (ANOVA) were performed. In this study, we use a statistical approach that takes into account the effects of secular changes in height. In order to control the cohort effect, the *Z*-value, i.e. standard deviation (SD)-normalized difference from the arithmetic mean of each individual, was calculated for the body height of each individual, according to the formula:  $Z = (\text{actual height} - \text{mean height}) / \text{SD}$ . Subsequently, Pearson's *r* coefficients of correlation were calculated separately for both sexes.

## RESULTS

The distributions for height and lifespan in men and women did not differ from the normal distribution. Men were taller than women (arithmetic mean  $\pm$  SD,  $171.6 \pm 6.6$  cm and  $159.6 \pm 6.2$  cm, respectively, *t*-test,  $p < 0.001$ ) and they had a lower age at death ( $67.9 \pm 13.8$  years and  $75.0 \pm 12.7$  years, respectively, *t*-test,  $p < 0.001$ ). For individuals who died at the age of 50 years and above, these results were as follows:  $171.1 \pm 6.4$  cm and  $71.1 \pm 10.8$  years for men and  $159.4 \pm 6.1$  cm and  $76.5 \pm 10.8$  years for women, all differences were statistically significant ( $p < 0.001$ ).

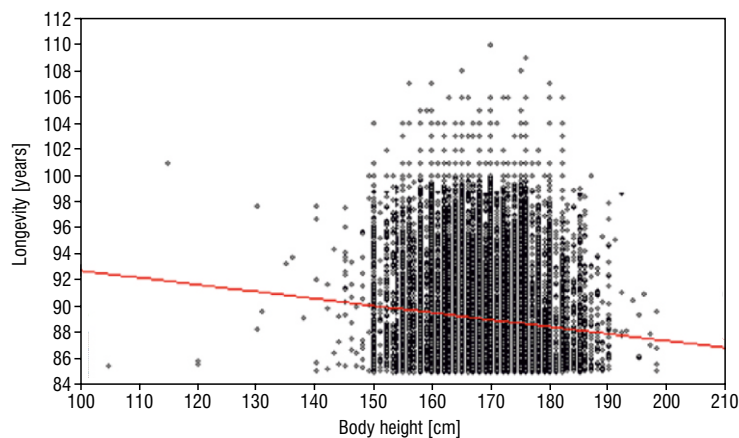
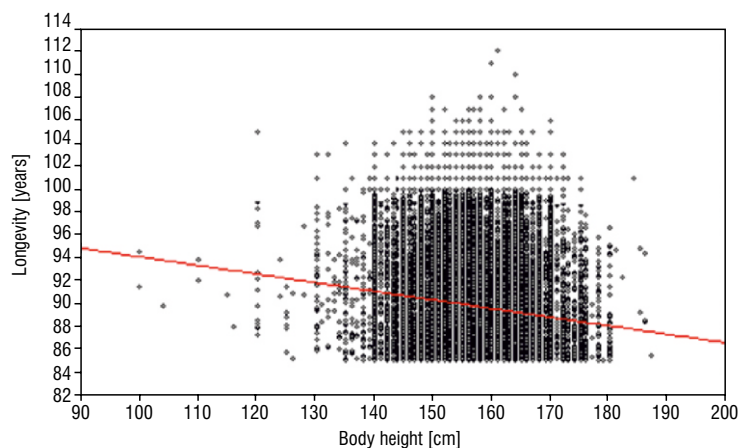
The analysis revealed that taller individuals had shorter lifespans compared with their shorter peers (Table 1). In individuals who lived for at least 50 years, longevity was inversely correlated with adult height in men ( $r = -0.27$ ,  $p < 0.001$ ) and women ( $r = -0.25$ ,  $p < 0.001$ ). For both sexes, the longest lifespan was

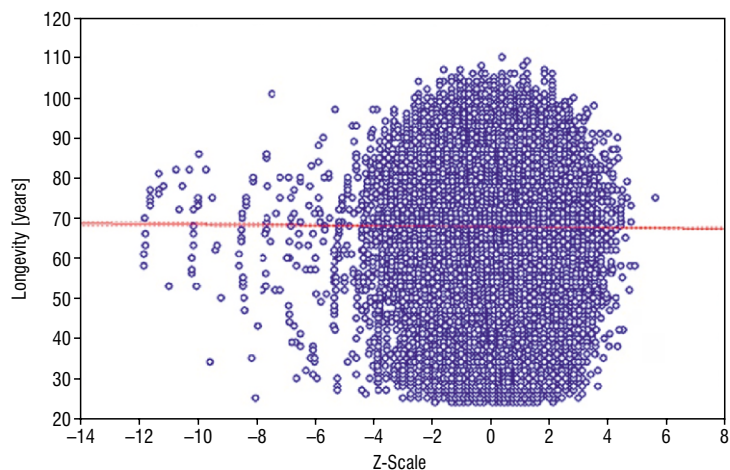
**Table 1.** Body height (arithmetic mean  $\pm$  standard deviation [SD], in cm) in adults who died at a given age in the years 2004–2008 in Poland

Age at death	Men			Women		
	N	Mean	SD	N	Mean	SD
50	12305	174.3	6.5	4312	162.1	5.7
55	171622	173.4	6.3	7373	161.7	5.8
60	19335	172.5	6.1	9181	161.6	5.5
65	18301	171.6	6.1	9447	161.0	5.7
70	25826	171.0	6.0	14903	160.3	5.6
75	30493	170.5	6.1	22658	159.8	5.9
80	27263	170.0	6.3	29103	159.1	6.0
85	17186	169.5	6.6	25836	158.5	6.1
90	5443	168.7	6.8	10983	157.3	6.2
95	2266	167.5	6.9	6009	156.5	6.4
100	261	167.0	6.9	820	155.3	6.3

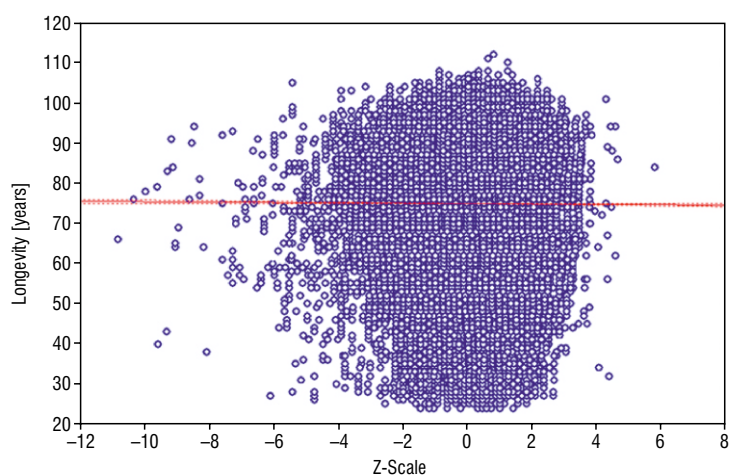
found for individuals born in December, and the shortest for those born in May. The amplitude of lifespan resulting from the month of birth effect was 16 months in men and 14 months in women. In the oldest old, i.e. people aged 85 years and above, there was an inverse relationship between body height and longevity (Figs. 1, 2).

When body height was plotted against lifespan, it turned out that smaller individuals, in general, had a longevity advantage. However, all of these effects waned after the calculation of the Z-values (Figs. 3, 4), when the influences of secular changes in body height were eliminated in the whole study sample. The coefficients of correlation were extremely low, i.e.  $r = -0.0044$  for men and  $r = -0.0038$  for women, but statistically significant ( $p = 0.023$  and  $p = 0.022$ , respectively).

**Figure 1.** The relationship between actual height and longevity in men aged 85 and above ( $N = 39,191$ ).**Figure 2.** The relationship between actual height and longevity in women aged 85 and above ( $N = 75,405$ ).



**Figure 3.** The relationship between normalised height and longevity in men ( $N = 483,512$ ).



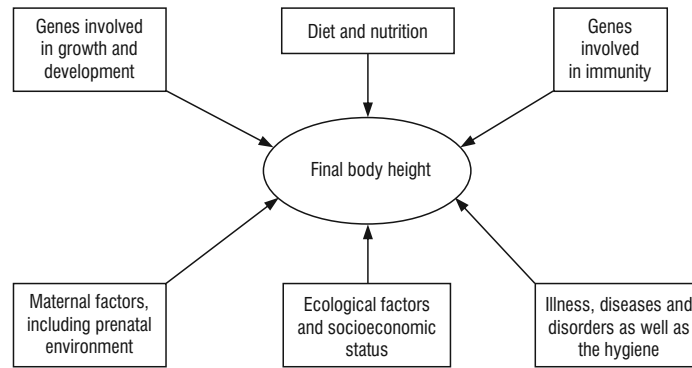
**Figure 4.** The relationship between normalised height and longevity in women ( $N = 365,348$ ).

## DISCUSSION

This research has revealed an inverse relationship between adult height and lifespan in both sexes, which is in agreement with several studies [9, 13, 28, 29, 32, 33]. Given that taller people have better nutrition and higher SES, including income and wealth [4, 19, 25–27], these findings convincingly demonstrate that taller stature is not associated with enhanced longevity in the studied population. Contrary to the popular belief that tallness is linked to better health and survival, these results strongly suggest that shorter people can outlive their taller counterparts. There are, however, both theoretical and empirical reasons for doubting that the observed relationship between stature and longevity is direct or causal. Probably, stature is just not a good predictor of longevity, and there are many other factors and processes at play.

It has been established that adult height represents the interactive effects of many processes [3], including the influences of genetic, epigenetic, nutritional, psychological, ecological and lifestyle-related factors such as pathogens, parasites, stress level, amount of sleep, diseases or disorders (Fig. 5). It should be remembered that not only environmental and lifestyle-related factors, such as an unhealthy 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 deficiencies, renal dysfunctions, heart failure etc., can result in short stature.

Beard and Blaser [3] argued that infectious diseases in childhood can negatively affect adult stature.



**Figure 5.** A constellation of factors that affect growth and development and are crucial for adult stature in humans.

Indeed, numerous studies have shown that children who suffered from diarrhoea and dehydration were significantly shorter as adults than those children who did not have these problems. For example, a study by Martorell and associates [20] demonstrated that in Guatemala children relatively free from diarrhoea during the first seven years of life would be around 4 cm taller than children more frequently ill with diarrhoea. Interestingly, it has been estimated that each episode of diarrhoea in childhood is associated with a decrease in adult height by roughly 0.6 cm [5]. 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 and conditions, such as chronic granulomatous disease, can also result in diminished final height.

Interestingly, taller stature might be associated with increased risk of cancer at different anatomic sites [14, 22, 28, 32, 34], even though it is unclear why taller and stouter people are more likely to develop cancer. However, tentative explanations can be offered. For example, taller and stockier individuals have significantly more cells in the body as opposed to their smaller and slimmer counterparts. It has recently been suggested that the sheer number of cells in the body can predict the relation between body size and cancer with no need to suggest additional factors [22]. 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 extra cells 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

replace older ones, is more likely to reach higher levels of chronic low-grade systemic inflammation, which is detrimental to health and survival [8, 10]. 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 is well known 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 years, and smaller individuals live longer [1, 2, 6, 21]. The data showing that smaller individuals outlive their larger counterparts suggest a role of biological factors (Table 2). Interestingly, animal studies indicate that caloric restriction reduces body size and extends lifespan. Additionally, several studies have demonstrated that tall people are less likely to reach advanced ages [7, 9, 13, 28, 29, 32–34].

However, several confounders, such as BMI, somatotypes, SES, educational attainment, smoking, health care etc., may influence the relationship between body height and longevity. Furthermore, it can be argued that adjusting for risk factors is a crude and inexact process. In addition, poor medical care can also affect results. Another confounder is that in upper economic classes, those who have spent their lives in the upper class are taller and have lower mortality rates than upper class individuals who were born in lower classes and worked up to the upper class. For example, a number of insurance studies have reported that taller men had lower mortality rates than their shorter counterparts. According to Samaras [29], body height is an index for greater body weight and thus BMI. Although taller and slimmer individuals can live longer than shorter and overweight people, greater body weight and BMI are related to increased mortality and morbidity.

**Table 2.** Putative mechanisms providing smaller people with a longevity advantage

Biological factors	Explanation
The total number of cells in the body	Tall people have more somatic cells, thus allowing greater exposure to DNA damage and molecular entropy. The sheer number of cells in the body predicts the relationship between adult height and cancer risk with no need to suggest additional factors [22]
Longer telomeres and more cell replications	Although the results are inconclusive, most studies indicate that longer telomeres are related to greater longevity. Some studies suggest taller nonagenarians have shorter telomeres [18]. Taller individuals use up more cells in the initial production of a larger body and in the daily replacement of damaged or dead cells they are at a disadvantage as they continuously need more cells as opposed to smaller individuals
Lower levels of GH and reduced insulin/IGF-1 signalling	Insulin/IGF-1 signalling is an evolutionarily conserved pathway that participates in various molecular processes and regulates lifespan across species. Reduced GH/insulin/IGF-1 signalling seems beneficial in terms of longevity. Taller individuals have higher levels of GH and more active insulin/IGF-1 signalling [1, 2]
Less hyperactive mTOR, which is a central hub of nutrient signalling	mTOR is an important sensor for nutrient signals that is involved in the longevity pathway. Taller and stouter individuals eat more as opposed to their shorter counterparts, assuming that larger and stockier individuals have more active mTOR, this central hub of nutrient signalling can be involved in the link between body size and longevity [6]
Desirable levels of certain biochemical parameters	Shorter and slimmer individuals who follow a healthy diet tend to have lower levels of total cholesterol and CRP and higher levels of SHBG [13, 28]

CRP — C-reactive protein; GH — growth hormone; IGF-1 — insulin-like growth factor 1 (also referred to as somatomedin C); mTOR — mechanistic (mammalian) target of rapamycin; SHBG — sex hormone binding globulin

### Limitations of the study

This study has limitations that should be acknowledged. Firstly, only declared body height was used. Secondly, the analysis did not consider potentially significant confounding factors, such as BMI, SES, educational attainment etc., as these data were not available. However, the relationship between adult height and longevity can be established based on the study sample used for the analysis. It should be stressed that shorter individuals score *worse* in terms of SES, income and wealth, and since taller individuals score *better*, the finding that taller individuals do not live longer than their shorter counterparts is even more intriguing.

### CONCLUSIONS

On balance, these results do not confirm the view that taller people live longer. The inverse relationship between height and longevity was reported for both sexes. After allowing for secular trends in stature, these effects waned but remained statistically significant, thereby suggesting that longevity favours smaller individuals in the studied population.

**Conflict of interest:** None declared

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