



# Evidence from Eight Different Types of Studies Showing that Smaller Body Size is Related to Greater Longevity

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## Author's contribution

*This whole work was carried out by the author TTS.*

## Mini-review Article

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## ABSTRACT

**Aim:** To report findings from various sources indicating that smaller sized humans live longer.

**Study Design:** Collected mortality and longevity data from a variety of diverse studies involving animals and humans. Also collected longevity data from many nations and ethnic groups. Evaluated a broad range of biological parameters that may explain why smaller people live longer.

**Methodology:** Over 145 mortality, life expectancy, and longevity studies were evaluated based on over 5000 papers, reports, and books collected over the last 35 years. Thirty studies were selected for this mini review to provide a balanced variety of findings.

**Results:** Evidence was collected on eight different types of studies. For example, studies were found showing smaller body size is related to greater longevity within the same species. Other studies involved longevity in relation to caloric restriction, male-female height differences, and US ethnic group heights. Other data sources indicated that shorter developed populations have longer life expectancies compared to the tallest populations. Longevity studies showed that shorter people lived longer. Worldwide, centenarians were also found to be short and lean based on their military heights or when adult heights were adjusted for shrinkage. A list of 11 biological factors identified why shorter, lighter bodies survive longer.

**Conclusions:** The evidence indicates that shorter, smaller bodies are healthier and longer-lived when healthful nutrition and lifestyles are followed. Therefore, emphasizing

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physical growth is unwarranted when children are healthy. Reduced caloric and animal consumption can provide a path for better health and avoidance of chronic disease.

*Keywords: Biological mechanisms of aging; caloric restriction; chronic disease; height; longevity; nutrition.*

## 1. INTRODUCTION

The belief that smaller body size promotes longevity is not a new idea and substantial evidence supports it [1]. However, it is not a popular position because of the worldwide bias favoring taller, bigger bodies as a sign of abundant nutrition, high standard of living and financial success. Therefore, the following data challenge conventional thinking about nutrition and height.

Many epidemiological studies have found taller people have lower heart and all-cause mortality risk. In addition, it has been assumed that our increasing life expectancy is related to improved economic development and nutrition that have increased our stature and weight. However, many researchers have associated the trend of increasing height as an adaptation to excessive nutrition [2]. In addition, our increased life expectancy is not due to better quality nutrition but to improved sanitation, immunization programs, and advances in medical care [3]. Nazmi and Monteiro also attributed increasing chronic diseases to the transition from traditional to modern diets [4].

In 2007, The World Cancer Research Fund [5] reported that changes in nutrition during industrialization increased our height, weight and chronic disease. For example, coronary heart disease (CHD) was rare in the early 1900s when we were considerably shorter than we are today. In addition, many societies following their traditional diets have low incidences of Western diseases until they adopt modern diets. These non-Western societies are predominantly shorter than Westerners.

This paper provides eight different types of studies indicating that smaller body size is better for human longevity. By deemphasizing growth, public health programs can emphasize healthful and moderate calorie nutrition with special focus on fetal, childhood and adolescent growth periods. The evidence, based on a variety of studies and ethnic groups, is presented in this paper. In addition, 11 mechanisms are identified that explain why smaller body size provides a biological advantage.

## 2. METHODOLOGY

Over 145 mortality, life expectancy, survival and longevity studies were evaluated based on over 5000 papers, reports and books collected over the previous 35 years. Caloric restriction findings were also reviewed. Thirty out of the 145 studies were selected for this minireview. Selection criteria included the size of the population evaluated, homogeneity of the population examined, diversity of geographical areas studied, and consistency of results. The largest longevity study selected involved 1.3 million men and the smallest about 400 individuals. A US government age-adjusted mortality report involved about 18 million deaths. Geographical areas included subjects from the US, Spain, Sardinia, Sweden, The Netherlands, China and Okinawa.

Examination of the various data collected indicated that they could be grouped into eight separate categories. These included the longevity of smaller individuals within the same species, smaller body size due to caloric restriction, male-female life expectancy, centenarians, US ethnic mortality in relation to height, life expectancy differences among developed countries, survival studies, and longevity studies. Each of these categories is summarized in this mini review.

Biological factors that could explain the greater longevity of shorter people were analyzed. Eleven mechanisms for the greater longevity of shorter people were identified by examining the literature describing how various biological parameters change with increasing height, weight and body mass index. These mechanisms were summarized in tabular form.

### **3. RESULTS**

The following results are divided into eight distinct sources of data that are relatively independent of each other. This section also includes a summary of 11 biological mechanisms that support the advantages of shorter, smaller body size. Virtually all these mechanisms are related directly or indirectly to nutrition, starting before conception. This section concludes with a summary of conflicting evidence and why this conflict exists.

#### **3.1 Within a Species, Smaller Individuals Live Longer**

Larger species generally live longer. However, the famous gerontologist, Alex Comfort, and many others have reported that within many species, smaller individuals live longer [1,2,6]. Dogs, horses, cows, mice, rats, and Asian vs. African elephants are examples of species in which the smaller animals live longer. Recently, a study of the tiny Brandt's bat showed that it lived longer than larger bats [7]. These tiny bats weigh 4-8 grams and live over 40 years.

Based on evaluation of 35 mammalian species, Promislow [8] reported that body size dimorphism is correlated with viability costs; that is, the larger of the two adult sexes has a higher mortality. In addition, the greater the size difference, the greater the viability cost. Moore and Wilson [9] also found that for males and females, sex size dimorphism correlates with parasitism, and parasitism correlates with mortality. In species where females are larger than males, the females have higher parasitism and mortality compared to the smaller males.

During the 20<sup>th</sup> C, small Okinawans had the highest life expectancy and percentage of centenarians in the developed world. Male centenarians averaged 147 cm and 47 kg [10]. Adjusted for shrinkage with age, they were about 152 cm tall in their youth. Okinawans also had 40% lower mortality rates for cardiovascular disease and cancer compared to taller and heavier mainland Japanese.

#### **3.2 Early Caloric Restriction Produces Smaller Animals That Live Longer**

Hundreds of experimental studies have shown that calorie restriction (CR) produces animals that are smaller and longer-lived. McCay, Crowell, and Maynard's CR studies were done almost 80 years ago and hundreds of subsequent studies provided consistent results. While life-long studies have not been made on humans, Fontana et al. [11] found humans on long-term CR with a well-balanced diet have much lower atherosclerosis, cell replication, and

inflammation. They also reported that CR protects humans from obesity, type-2 diabetes and hypertension.

The children of the long-lived Okinawans consumed 36% fewer calories than mainland Japan [12]. During adulthood it was 17% less than the mainland. The Okinawans in the recent past had a higher life expectancy than the taller, heavier mainland Japanese. They also had a 40% lower mortality from cardiovascular disease and cancer. However, when their children are born on the mainland, they get taller and bigger and lose their longevity benefits.

Indirect evidence also comes from the Great Depression [13] with its widespread reduced food availability that saw much lower mortality rates for virtually all age groups, including infants. In addition, over a 3-year period, life expectancy jumped by over 6 years. Several other examples, such as Europe during WW II, the Cuban economic disaster in 1990-2000 and the Chinese Great Leap Forward Famine, support the Depression findings. For example, Europeans saw a sharp drop in CHD and other chronic diseases during the war. When food supplies returned to normal after the war, chronic diseases increased again. The Cubans saw a reduction in heart disease, diabetes and all-cause mortality during their 10-year period of reduced food supplies and calories. The Chinese Great Leap Forward Famine also found that adults born during this famine had longer life expectancies compared to those conceived and born after the famine [14].

### 3.3 Smaller Females Live Longer

A comparison between male and female life expectancy reveals an interesting inverse relation between height and life expectancy among a variety of populations. For example, US males are 9% taller than females and have a 9% lower life expectancy [15]. Another report shows Polish men are 7% taller than women and have a 7% shorter life expectancy (Boryslawski, Chmielewski and Chmielowiec, unpublished data, Apr 30, 2012). The loss of life with increased height for American and Polish men is identical at 0.5 yr/cm. This number is also identical to a longevity study of US male veterans, an Ohio longevity study of men and women, and a Swedish mortality study of men and women. That is, they all found a loss of life with increasing height of 0.5 yr/cm [15]. The number 0.5 yr/cm was rounded to the nearest tenth for examples given.

Based on a study of a deceased Ohio population, Miller [16] found that when men and women of the same height were compared, they had about the same longevity. Rollo [17] also found that the difference in longevity between male and female rodents was due to their difference in body size. In addition, small male dogs live longer than big female dogs. As mentioned, Promislow [8], Moore and Wilson [9] found that in species that have larger females compared to males, the females generally experience higher mortality rates compared to smaller males.

### 3.4 Most Centenarians are Small

Roth et al. [18] reported that many centenarians are slim and small in height. In addition, most peer-reviewed studies show centenarians are generally short and small. For example, a recent study from Cuba found males averaged less than 158 cm adjusted for shrinkage [19]. Most centenarians vary from 155 to 165 cm. However, a study of US WW I veterans found that men of medium height represented the largest proportion of centenarians [20]. In

contrast, Chan, Suzuki and Yamamoto found short height favors reaching 100 years [21]. Many biologists also firmly believe that smaller bodies tend to live longer [20].

Sardinians are the shortest people in Europe and have the highest percentage of centenarians [22]. While women normally over represent the centenarian population by about 5 to 1, a village in Sardinia, Villagrande Strisaili, had a 1 to 1 ratio. The males in this village were the shortest in Sardinia and had the highest percentage of centenarians in Sardinia.

### **3.5 Lower Mortality of Shorter Ethnic Groups**

A US government report (Health, United States, 2001) showed that Asians had the lowest age-adjusted mortality of all ethnic groups [15]. Latinos and Native Americans were higher. The highest mortality rates applied to Blacks and Whites. Blacks and Whites were the tallest and Asians were the shortest. Latinos were taller than Asians and Native Americans were taller than Latinos. The report was based on about 18 million deaths throughout the US over a 15-year period. Additional support comes from Europe during the 20<sup>th</sup> century. For example, Northern Europeans had substantially higher all-cause mortality compared to shorter Southern Europeans. They also had higher death rates from heart disease and cancer [23].

### **3.6 Populations with the Highest Life Expectancy are Shorter than the Tallest Populations**

Six populations with the highest life expectancy were compared to the tallest populations in Western Europe. These six populations were Andorra, Macao, Japan, San Marino, Singapore and Hong Kong. Their average rank was 3.5 from the top. In contrast, the six tallest populations averaged about 28<sup>th</sup> from the top. The six top populations in life expectancy were shorter than the tallest, which were Sweden, Norway, Denmark, the Netherlands, Germany and Finland [15].

### **3.7 Survival Studies Show Shorter People Live Longer**

A number of studies show that shorter height men are more likely to reach advanced ages. For example, a long-term study of Japanese-Hawaiian men found that as they got older, the men surviving were shorter [24]. Using their baseline heights, men who reached 100 years of age were about 2 cm shorter. Another long-term study of Swedish men found that at 67 years of age, shorter height predicted that they were more likely to reach 90 years of age [25]. Maier et al. also reported that 90 year olds that were shorter than their age-peers were more likely to live longer [6].

### **3.8 Longevity Studies Favor Shorter People**

Over 15 studies of deceased people show that shorter people live longer. For example, a Sardinian study found that shorter men lived about 2 years longer than taller men in a small village [22]. The average height of these men was 160 cm based on military records.

A 70-year study of 1.3 million Spanish males found that shorter men lived longer [26]. The heights of the males were based on military records. The principal author reported (unpublished report) that the men lost 0.7 yr/cm of increased height.

A US study of a population of about 1700 deceased males and females found that shorter men and women lived longer [16]. In addition, a study of US baseball players based on 3200 deceased players found that shorter players lived longer [15]. Studies of football and basketball players and famous people found similar results. A list of over 35 research and review papers showing that shorter people live longer is available from the website: [www.humanbodysize.com](http://www.humanbodysize.com).

### 3.9 Biological Mechanisms Support the Findings

A summary of biological mechanisms that support the previous findings is given in Table 1. The most powerful factors include greater cell replication potential into old age, lower DNA damage with decreasing height, lower free radical damage, decreased cancer risk, smaller left ventricles and higher sex hormone binding globulin (SHBG). Keep in mind that the biological mechanisms listed assume that we are comparing short and tall people of similar body proportions following similar life styles. Note that weight and BMI normally increase with height [29].

**Table 1. Biological mechanisms explaining longer longevity of smaller humans**

| <b>Biological Mechanism</b>  | <b>Remarks</b>  |
|--|---|
| Reduced cell replications and longer telomeres [6,27]                              | Longer telomeres increase longevity and decrease cardiovascular disease (CVD).  |
| Reduced DNA damage [28]  | DNA damage decreases with shorter height.   |
| Lower free-radical generation [28]   | Lower DNA, cellular, protein, and fat damage.   |
| Lower cancer risk [15,28,30]   | Lower cell number and fewer free radicals reduce exposure to carcinogens.   |
| Lower Body Mass Index (BMI) [29]   | Mortality decreases progressively with decreasing BMI within healthy BMI range.   |
| Larger organs in relation to body weight [29] (heart and lungs follow body weight) | Larger organs have greater functional capacity.   |
| Lower insulin and insulin-like growth factor-1 [1,27,30]                           | Lower levels are major factors promoting longevity.   |
| Higher sex hormone binding globulin [30]   | Higher levels protect against CVD/cancer.   |
| Reduced C-reactive protein (CRP) and glucose levels [30]                           | Mortality decreases progressively with lower CRP and glucose levels.  |
| Reduced left ventricular mass (LVM) [29,30,31]                                     | All-cause and CHD mortality decline with lower LVM. This relation is independent of other risk factors. LVM is reduced by shorter height, lower weight and lower BMI. |
| Lower blood pressure [27,30]   | Lower blood pressure is related to lower risk of CVD and stroke.  |

### 3.10 Conflicting Findings

Gavrilov and Gavrilova [32] found that height is not a major factor for exceptional longevity. In contrast, many mortality studies find that taller people have lower mortality rates. However, most mortality studies are not longevity studies. Since mortality studies generally don't track short and tall cohorts until they are all deceased, they can miss cross-overs at

older ages. For example, in the US, Latinos have much higher mortality rates before ~55 years of age but after that age, mortality starts dropping, and their overall mortality is substantially lower than the taller White population.

Most studies show that shorter people have more CHD than taller ones. However, these studies are challenged by many worldwide findings showing short people have very low to no CHD or stroke [27]. In addition, in the early 1900s, US males were many centimeters shorter than today and had very little CHD compared to present day taller men. A recent study [33] found that the Great Dane had 70 times the risk of heart failure compared to the miniature Dachshund ( $\leq 5$  kg). In addition, the larger standard Dachshund had 3 times the risk as the miniature Dachshund. This finding is consistent with studies finding many short human populations are free of CHD [27]. It should be noted that very low CHD has been found in a variety of shorter ethnic groups, including Pacific Islanders, Europeans, Asians and Africans.

A number of confounders also explain the conflict between the findings in this paper and many epidemiological studies. For example, taller height is correlated with higher economic status, which is correlated with taller height in both developing and industrial populations. Lower economic status is also related to increased cardiovascular risk independent of other risk factors. In addition, poor people tend to be obese and shorter and low birth weight adults who experienced catch-up growth have higher risk for chronic diseases and reduced longevity [1,34]. Another confounder may be that a substantial number of adults in the developed world may have had pathological conditions as children that stunted their growth and affected their adult health.

## **4. DISCUSSION**

The following material provides taller people reasons not to take the findings personally. In addition, the importance of these findings to nutritionists and anyone interested in public health are discussed. The need for future actions is also described.

### **4.1 How Should Taller People Deal With These Findings**

Taller people should not become apprehensive about these findings. The findings in this paper are similar to the established fact that women live longer than men. However, while women overall have higher life expectancies than men, numerous men still live substantially longer than the average woman. In addition, many tall men live to advanced ages, including 100 years of age. For example, John Kenneth Galbraith was 203 cm and lived to 98 years of age. Since height is only about 10% of the longevity picture, many other factors affect how long an individual will live. These factors include economic status, body mass index (BMI), nutrition, smoking, excessive alcohol intake, exercise and genetics. While adjustment for risk factors are normally made, these adjustments are crude and inexact and may miss important risk factors. The importance of economic status is especially important because richer people tend to live over 5 years longer than poor people.

### **4.2 Why Nutritionists and Public Health Practitioners Should Be Concerned**

Scientists have focused on the carrying capacity of the earth in terms of how many people live on earth. Most agree that we can't continue increasing the number people in the world without serious consequences. However, they tend to ignore increasing human body size as

has occurred in the US during the last century. For example, a 33% increase in male weight occurred over the last 100 years. If we assume a current world average of 59 kg (130 pounds), this converts into an increase in human biomass from 455 to 606 million tons. This increase has a major impact on the earth's capacity to provide enough food, water and resources to sustain this larger population. Consequently, the trend in increasing weight is related to both increased height and obesity and cannot be ignored without risk of future devastation to our civilization.

Another problem to consider is a continual increase in the height of the average human. With advances in genetic engineering and our continued admiration of taller height, parents will have their embryos genetically modified for taller stature. This artificial increase in human height could proceed for many generations creating very large humans. The consequences of this scenario will be massive demands for more food, water, resources and energy. Of course, this added consumption will negatively impact other species and our environment with the potential to threaten our ability to survive as an advanced civilization.

## **5. CONCLUSION**

Substantial evidence from a variety of sources and ethnic groups indicates that smaller human size is an advantage under similar lifestyles and medical care. We need to get away from our idolization of increased height and weight. Our emphasis on higher birth weight, rapid growth and taller stature has produced an unhealthy and obese population. Over 15 years ago Cryan and Johnson [35] warned that infants and young children are being overfed by about 20%. In 2013, Tam Fry of the Child Growth Forum reiterated that infants and young children were being overfed.

The potential for an economic crisis due to the high costs of treating widespread illnesses has been reported by many researchers [4]. This potential crisis should help us focus on moderate and healthful nutrition from pregnancy through adulthood [33]. However, we have to accept that a reduced calorie and plant-based food system will lower the average height and weight of our population by a modest amount.

## **6. POST FINDING**

After this paper was submitted for review, a new study was found that relates to the preceding findings. The study involved tracking 8006 middle-aged Japanese Hawaiians for over 40 years. The researchers of this unique study found that men  $\leq 158$  cm have a better survival in old age compared to men  $\geq 165$  m. Citation: He Q, Morris BJ, Grove JS, Petrovich H, Ross W, Masaki KH, et al. Shorter men live longer: association of height with longevity and FOXO3 genotype in American men of Japanese ancestry. *PLoS ONE*, 2014, 9: doi: 10.1371/journal.pone.0094385.

## **ETHICAL APPROVAL**

The author hereby declares that no experiments have been conducted in the preparation of this paper.



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## COMPETING INTERESTS

Author has declared that no competing interests exist.

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