International Data Demonstrating the Inverse Height and Life Expectancy Between the Sexes

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Abstract

Many papers have provided reasons for why women live longer than men. These include XX vs. XY chromosomes, sex hormones, and better care of their health. These factors certainly can affect male and female health but none has been proven to explain the actual difference that exists in life expectancy between the sexes. Another controversial factor commonly ignored is the size difference between men and women, but past research has shown that differences in male and female height and associated life expectancy are related by similar but inverse percentages (such as 8% taller and 9% shorter life expectancy). This paper provides additional evidence that supports early findings that shorter height is a major factor in explaining why women live longer. To test the inverse relation between height and life expectancy, a list of developed countries was used to compare height and life expectancy differences between men and women. The results showed men were 7.8% taller and had an 8.5% lower life expectancy. These results are similar to previous study findings in 1992, 2003, and 2009. They are also consistent with scores of studies showing shorter or smaller body size is related to greater longevity independent of sex.

Keywords: gender differences, life expectancy, height, mortality, longevity, body size, telomeres

1. Introduction

For decades the proposition that females live longer than males has been perpetuated in both the popular and academic literature. These writings suggest that a simplified bivariate relationship is the cause of differences in longevity. Over the decades, college students have accepted this impression from reading standard gerontology textbooks. Many of these books report that females outlive their male counterparts without further elaboration. Thus, college students accept an overly simplistic bivariate explanation of sex as the predominant independent variable for longevity. To make matters more convoluted, we find an emotional attachment to this overly simplistic bivariate model. This attachment has been found in informal conversations at conferences and office meetings with professors of gerontology.

In the 1950's the popular belief was that women lived longer than men because women did not face the stressed dominated environment of the workplace. Madigan [1] produced an exceptionally well-controlled study with a large sample demonstrating that the stress argument is false. He was able to get well-documented data from monasteries (monks) and convents (nuns) whose daily activities were virtually identical in terms of social-psychological stress factors. Nuns lived significantly longer than monks. Madigan's work forced researchers to look at more complex causal features—such as height and weight.

In contrast to other disciplines, many biologists believe that within species, smaller individuals live longer [2]. Dogs are an excellent example supporting the biologist's viewpoint. Canines have been studied extensively and there is a strong inverse relationship between body size and longevity [3-5]. Mice [6], horses, and cows have also shown this relationship although studies have been less formal for horses and cows. Promislow [7] and Moore [8] also studied numerous species and found that larger males within species generally have higher death rates and their mortality increases with increasing body mass. They also found that when the females within a species are larger than males, they have higher mortalities than smaller males. Ringsby [9] and Barrett [10] programmed birds to reduce their length and body size and found these smaller birds lived longer. They attributed this greater longevity to the longer telomeres of smaller individuals.

It is well established that larger species tend to live longer than small ones, and this fact promotes the misconception that within species larger individuals live longer. However, this belief does not appear to be true. For example, Bartke [11] described a number of mechanisms that explain why smaller size is related to greater life expectancy (LE). He also noted why many scientists believe bigger is better due to the correlation between secular growth and the increase in human longevity over the last few centuries. However, extensive research involving animal studies, caloric restriction, biological parameters and human mortality and longevity studies show that smaller humans with similar environments have many health and longevity advantages.

Since body size is a function of height, weight and body mass index, many of the mortality and longevity studies have used height as an index of body size. Height and lean body mass generally increase together [12], and females in most developed countries are shorter, lighter and have a lower body mass index. Over a lifetime, height varies much less than weight or body mass index. Thus, this study uses height as a measure of body size differences between the sexes. For example, a young 5'9" (175 cm) male may shrink less than 2" (5 cm) by 80 years of age. Thus 2" /69" (5 cm/175 cm) equals less than 3% shrinkage over a lifetime.

Since 1978, human longevity studies have found a variety of populations show shorter or smaller males and females live longer or have lower mortality rates [13-29]. Although studies of shorter women living longer are less common, several studies have found that shorter women have lower mortality or longevity rates [20, 22, 23]. A review of the biological factors that explain why shorter, smaller people live longer was also published recently [30]. These biological factors include longer telomeres, lower DNA damage, fewer cells subject to carcinogens, and larger organs with greater functional capacity in comparison to body weight. Note: the heart and lungs are different in comparison to other organs in that they are proportional to body weight.

An overview [31] of findings summarized the various types of studies, populations (including athletes) and ethnic groups evaluated by different researchers. While there was a wide range in the numbers of people in these studies, most involved thousands of individuals and one study included about 1 million deceased men. A US mortality study involved about 18 million subjects [31] and a Hawaiian study [19] tracked the mortality of 8000 elderly Japanese Americans over a 40-year period. Note that a number of researchers did not find a relation between height and mortality or survival until 60, 70 or 80 years of age.

Over the years, scientists have labored over the causes for women living longer than men. They have identified differences in XX and XY chromosomes, hormones, cancer and life style as the causes of their greater LE [32]. While at least some of these factors play a role, this paper examines an entirely different possibility. Since women are generally shorter and lighter than men, we examined the inverse relationship between height and LE and provide evidence that LE differences between the sexes are due to their different heights. It should be pointed out that females have earlier maturity, a higher heart rate, more complex physiology, and carry one or more fetuses in their bodies for 9 months that may affect their health and longevity. However, research is needed to evaluate the effects of earlier maturity, higher heart rate, and reproductive complications on female health.

Findings on male-female longevity support previous reports by several researchers over the last 27 years [17, 20, 33]. For example, previous papers identified about 10 populations that show a very close inverse relationship between the heights and life expectancies (LE) of males and females. This paper expands these findings by exploring additional populations. We chose to compare the differences in height and longevity between males and females in developed countries. The World Factbook [34] provided a list of 31 countries and this database was used for the calculations in this paper. The method of data sampling and evaluation is described next.

The data sources selected expand previous findings related to male-female longevity differences. These previous studies showed that taller males tend to have decreased longevity vs. shorter males similar to the differences found in this paper [13, 16, 17]. However, earlier studies mainly focused on specific groups within the US. The data selected for this study represent a larger variety of countries with similar economic backgrounds. The height and life expectancy data in this study were evaluated to determine whether previous longevity studies [11,13-29] are supported by a broad range of male vs. female longevity differences. The entropy theory predicts that larger, higher energy bodies within the same species exhibit more rapid increases in disorder (aging) over human lifetimes [17].

2. Methods and materials

Sample selection

Recently, a number of male vs. female evaluations (unpublished) were made for various countries. However, they included both developed and undeveloped populations, and some countries, such as Central and Eastern European countries, had large differences between the percent difference in male height and the percent lower life expectancy (LE). All these tests showed an average height difference of ~8% taller and ~9% shorter LE for males vs. females. It was decided to expand these findings and to look at only developed countries for this study. A search of the internet identified a list of 31 countries provided by the 2018 World Factbook [34]. These countries represent millions of adults. In addition, countries in this list included various geographical locations, such the US, Canada, Germany, France, Sweden, Japan, Singapore, Israel, South Korea and Australia. An advantage of using developed countries is that their health data are more reliable than those of underdeveloped countries.

Sources of height and life expectancy statistics

The major two sources used for height and life expectancy were List of Average Human Height Worldwide from 2018 [35] and Timonin et al. [36] from 2016. The 2018 World Bank Life Expectancy at Birth data [37] were used for a few countries that were not listed in Timonin, et al. [36].

In some countries, multiple height entries were available. For this study, selection was based on measured vs. self-reported heights. In addition, when multiple age groups were specified for a country, heights were selected for age groups as close to 20 years of age as possible.

Each country in the list had male and female height differences calculated in percentages; e.g., the difference in height between sexes was divided by the height of females to compute the percent taller male height. The difference in LE between the sexes for each country was divided by the LE of females to obtain the percentage lower longevity for males compared to females. The heights, life expectancies, percent larger male height differences and percent lower LE differences of males in comparison to females were recorded in separate columns as shown in Table 1. The average differences in height and LE were calculated for the entire list of 30 countries and added to the bottom of the table.

Cyprus was the only country omitted from these calculations because female height for Cyprus was not available from the primary height source or other sources that were available. Five countries did not have LE data provided in the primary source [36] and these data were obtained from the World Bank Life Expectancy report [37].

Statistical method

Two statistical tests were made to evaluate whether significant differences exist between (1) male and female height and (2) male and female life expectancy. Two unmatched t-tests were used for this evaluation.

3. Results and Discussion

Table 1 lists 30 countries with four columns for height and LE data for males and females. Two additional columns identify the percentage differences in height and LE between the sexes under the two columns designated as Delta.

The average age at height measurement was 23 years of age. The average year of height data was 2006. Thus, the year of birth was about 1983. Timonin's et al. [36] paper provided life expectancy at birth for 1984 and this birth year was used to collect LE data for each country. Timonin's et al. list [36] did not provide LE data for five countries. The World Bank life expectancy (2018) [37] source was used for these five countries in Table 1: Greece, Israel, Slovenia, S. Korea and Singapore.

Table 1: Male vs. female height differences are inversely related to life expectancy (LE) in years at birth (30 deleveloped countries) *

Country	Height (inches)		Delta %	Life Expectancy		Delta %
	Male	Female	Taller	Male	Female	Lower LE
Australia	70.00	64.50	8.50	72.66	79.21	-8.30
Austria	71.00	65.50	8.40	69.96	77.14	-9.30
Belgium	70.50	66.00	6.80	70.92	77.16	-8.10
Canada	69.50	64.50	7.80	73.01	79.79	-8.50
Czech Republic	71.00	66.00	7.60	67.28	74.44	-9.60
Denmark	72.00	66.50	8.30	71.63	77.61	-7.70
Estonia	70.50	65.00	8.50	64.57	74.26	-13.00
Finland	71.00	66.00	7.60	70.47	78.76	-10.50
France	69.50	65.00	6.90	71.13	79.35	-10.40
Germany	70.50	65.50	7.60	71.24	77.89	-8.50
Greece	69.50	65.50	6.10	72.00	78.00	-7.70
Iceland	71.50	66.00	8.30	74.75	80.19	-6.80
Ireland	70.50	64.00	10.20	70.88	76.53	-7.40
Israel	69.50	65.50	6.10	73.00	77.00	-5.20
Italy	69.50	64.00	8.60	72.12	78.75	-8.40
Japan	67.50	62.50	8.00	74.62	80.30	-7.10
Luxembourg	70.75	65.00	8.80	69.54	76.55	-9.20
Netherlands	72.00	67.00	7.50	72.95	79.67	-8.40
New Zealand	70.00	64.50	8.50	71.16	77.67	-8.40
Norway	72.00	66.00	9.10	72.91	79.49	-8.30
Portugal	68.50	64.50	6.20	72.13	76.44	-5.60
Singapore	67.50	63.00	7.10	71.00	76.00	-6.60
Slovenia	71.00	66.00	7.60	67.00	76.00	-11.80
S. Korea	68.50	**63.00**	8.70	64.00	70.00	-8.60
Spain	69.50	65.50	6.10	73.20	79.68	-8.10
Sweden	71.50	65.50	9.20	73.82	79.92	-7.60
Switzerland	69.00	64.50	7.00	73.34	80.02	-8.30
Turkey	68.50	63.50	7.90	58.00	65.00	-10.80
United Kingdom	70.00	65.00	7.70	71.86	77.72	-7.50
United States	69.50	64.00	8.60	71.12	78.17	-9.00
*** Averages:**	**Greater Height: 7.8%**			**Lower LE: -8.5%**		

The average increase in male height compared to females is 7.8%. The average decrease in LE for males compared to females is 8.5%. Rounding to the nearest integer results in an increase of 8% in height for males compared to an 8% lower LE compared to females.

However, for individual countries, the differences are not as consistent. For example, Estonia, Finland, France, Slovenia and Turkey have over 10% lower LE compared to about 8% greater height. In contrast, 17 countries had height and LE differences of less than 1%; e.g., 8% vs. 9%.

Five other non-published evaluations were made and the differences were similar to Table 1. For example, the first 20 countries identified in the 2018 List of Average Height Worldwide [35] were selected. In addition, LE data were obtained from the 2018 List of Countries by Life Expectancy [38]. This sample included a combination of developed and developing nations. The average difference in height between the sexes was 7.9% taller and the difference in life expectancy was 6.5% lower.

The statistical tests from data in Table 1 comparing males and females were statically significant as follows:

Unmatched t-test for height: $t = 5.982$; $df = 26$; $p < .0005$

Unmatched t-test for life expectancy: $t = 9.38$; $df = 26$; $p < .0005$

It is surprising that the difference in height can so accurately predict differences in longevity. However, height is positively related to weight and we know that larger body mass is related to poorer health [12]. While height is independently related to some factors, it does not explain the total difference in life expectancy. In addition, height is likely a reflection of other factors that affect LE, such as longevity genes FOXO3 [19] and Laminin Alpha 5 [39]. Also, an increase in body size parameters, such as height, weight or BMI, is negatively related to many biological parameters [30]. However differences in body mass between the sexes may not always show that women have lower levels of undesirable parameters, such as IGF-1 and insulin, although they tend to increase within both sexes with height, body weight or body mass index. Women do have higher adiponectin and lower mTOR—both trends are related to greater longevity [30].

Compared to men, these levels correspond to lower body mass. In addition, longer telomeres are correlated with the lower height and body mass of women. For example, Maier et al. [28] showed males were 8.6% taller than females and had a 7.6% lower cell doubling potential [shorter telomeres]. (These percentages were calculated from Maier's data.) In addition, Giovannelli, et al. [40] found DNA damage was positively correlated with height. Their findings indicate that the DNA damage increases exponentially with height. It appears that DNA damage and reduced telomere length have important roles in longevity. In addition, Brown-Borg, et al. [41] found that smaller dwarf males were deficient in growth hormone and lived longer than their normal size female siblings.

Inspection of the data in Table 1 shows that within a specific country, there can be up to a 4.5 % difference between the greater height of males and their lower life expectancy; e.g., 6 countries had a 2.8 to 4.5% difference in life expectancy and height percentages. In contrast, 17 countries showed less than a 1% difference between height and life expectancy percentages. Larger differences in percentages between height and life expectancy are probably due to life style differences between males and females within their countries. For example, smoking, drinking, drugs, and accidents may reduce male LE by a larger amount than for other countries with different health and lifestyle practices.

The remarkably close inverse relation between shorter female height and longer longevity compared to male parameters appears to be highly consistent. This is especially true when the percent decrease in longevity of taller vs. shorter men corroborates the male vs. female findings. For example, three male-to-male comparisons are listed below:

1. Deceased US veterans were 6.4% taller had a 6.9% lower longevity compared to shorter deceased veterans [13].

2. Deceased US baseball players were 4.5% taller had a 4.6% shorter longevity vs. shorter deceased players [13].

3. Finnish basketball players were 7.9% taller and had an 8.7% lower LE compared to shorter cross-country skiers [17]. (Percentages were computed from data provided in reference source.)

While the results shown in Table 1 and various studies show that height and body size are inversely related to longevity, many men outlive the average woman. For example, some centenarian populations include up to 25% males. Thus, these men outlived the average woman by about 2 decades. In addition, a study of Sardinian centenarians found men represented half the population [25].

Many mortality studies show taller people have lower coronary heart disease or all-cause mortality compared to shorter ones. However, in recent years, three large mortality studies found shorter people have lower mortality [22, 23, 24].

Most mortality studies are affected by several confounding factors. For example, most studies don't track subjects through advanced ages, but the studies by Mueller, Salaris, and He, indicate that the longevity benefits of shorter height do not show up until after 60, 70, or 80 years of age [15, 18, 19]. Therefore, tracking all subjects into advanced ages provides more reliable results as indicated by the referenced researchers. In addition, it is difficult to account for childhood stunting and the harmful effects of malnutrition, childhood illness, and stress/trauma on adult health. All of these factors can reduce adult height, health and longevity. Catch-up growth of low birth weight infants is also related to adult chronic disease and mortality [42]. Other important factors are socioeconomic status during different periods of one's life [43] and the tendency for shorter people to be overweight [12, 44]. For example, if people are compared who are in a higher income bracket, those who were poor in childhood will be shorter than people who have been well off all their lives [43]. As result, the study would falsely relate shorter height to higher mortality when the real causes are related to being poor in earlier years.

4. Conclusions

The broad-band evidence that 21st century shorter women live longer than taller men is indisputable. The reason for this appears to be that smaller individuals age slower under similar socioeconomic conditions and life styles. The evidence relating smaller body size to better health and longevity is strong and consistent, and it indicates that larger human size places a burden on our biological systems that result in increased chronic disease and reduced longevity. Shorter telomeres and higher levels of IGF-1 and insulin appear to play major roles in reducing the longevity of larger individuals [30].

The question, of course, is what should be done about this situation. The answer lies in nutrition. T Colin Campbell has attributed our increased height and chronic disease to excessive consumption of animal protein [45]. However, this conflicts with the popular thesis that large babies, faster growth, early maturity and greater height and body weight reflect a healthful combination [42, 46, 47]. The findings in this and many other papers indicate that this thesis is not true based on widespread chronic disease and obesity in the modern world [17]. In addition, many studies have found that higher birth weight is correlated with future overweight or obesity, cancer and increased type-2 diabetes [17]. For example, Samaras reviewed findings that showed higher birth weight and rapid growth promote cancer and reduced longevity [48]. He also showed that higher birth weight and rapid growth promote overweight and obesity. In addition, children who experience adiposity rebound before 5 years of age average 4.5 BMI points higher in adulthood compared to those that grow slower and reach adiposity rebound after 7 years of age. Previous studies also provide a list of 12 populations where the individuals lose an average of 0.51 years per centimeter of increased height (-0.35 to -0.70 yr/cm) [16].

Nutritionists need to redesign our current food practices so that smaller infants can be healthy and grow more slowly with a lower increase in BMI. The nutrition followed by pre-Western people shows that children can be lighter at birth and grow slower and smaller with virtually no Western chronic diseases [49]. An improved nutrition paradigm combined with modern hygiene, sanitation and medical care could improve the lives of billions of people and reduce the odds of economic disaster related to unbearable medical costs. It would also have many personal and ecological benefits.

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Author contributions

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