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How height is related to our health and longevity: A review

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Abstract

Most people believe that being taller and heavier is a sign of higher social status and privilege; however, an objective evaluation of the advantages and disadvantages of increased body size (excluding obesity) indicated that shorter, smaller bodies have numerous advantages in terms of health and longevity. With healthful nutrition and lifestyles, and good medical care, shorter people are less likely to suffer from age-related chronic diseases and more likely to reach advanced ages. A variety of biological factors explain the inherent benefits of smaller bodies. These include reduced cell replication, much lower DNA damage and reduced cancer incidence. Other beneficial factors include higher sex hormone binding globulin, higher insulin-like growth factor binding protein-1, lower insulin and lower insulin-like growth factor-1. We discuss recommendations for how taller people can minimize their risks. Future public health practices should focus on healthful nutrition, without promoting continued secular growth in height and weight.

Keywords

Blood pressure, cancer, cardiovascular disease, centenarians, chronic disease, free radicals, health, height, insulin, insulin-like growth factor-1, longevity, mortality, nutrition, risk factors, sex hormone binding globulin

Background

Taller height is a sign of social status and privilege (Cole, 2000). In addition, taller people are viewed as being healthier, smarter, stronger and better leaders throughout most of the world, including places where people are relatively short, such as China. The

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reason for this belief is based on the fact that taller people are more often from higher socioeconomic classes and therefore have superior environments, education, medical care and opportunity that promote higher human development. In contrast, very little attention is given to the achievements of shorter people; e.g. many of the world's greatest achievers have been on the short side, such as: Einstein, Millikan, Michelson, McClintock, Mozart, Mahler, Beethoven, Churchill, Alexander the Great, Premier Deng, Joan of Arc, Gandhi and Martin Luther King. In addition, no one mentions that many relatively short societies demonstrate outstanding intellectual achievements, such as: ancient Egypt and Greece, the Elizabethan period, 16th century Netherlands, and the Tang and Ming dynasties. Furthermore, modern Chinese, Japanese and South Koreans have also shown the capacity for outstanding achievement. Also, India is making remarkable progress in recent times and Indians are noted for their academic achievements. The people who created these modern nations during the 20th century were substantially shorter than the current beneficiaries in those societies.

A factor involved in the admiration of greater height and weight, during the last 150 years, is the large increase in Western life expectancy that parallels our increased height and weight. In contrast, people in the developing world are smaller and have a much lower life expectancy; however, a number of researchers question the association between our nutritional system, increased height and life expectancy. For example, Peter Farb, a consultant to the Smithsonian Institution, states that our admiration of increased height is a false idol, because greater height reflects over-nutrition and poorer health and longevity, rather than better quality nutrition (Samaras, 1994). Stini, Walker, Kaplan and Toshima also attribute health risks to our increasing height (Samaras and Elrick, 1999). John Waterlow (Cannon, 2013), discussing the relationship between increased body size and consumption, also states: "We will have to accept that future generations will be smaller and leaner and perhaps slower."

The World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) (2007) reports that the move to urban living and industrialization has promoted increased height, weight and chronic disease. This report also attributes the Western diet to the increase in chronic disease, in recent times. In addition, Trowell and Burkitt's (1981) book on Western diseases reported this finding over 30 years ago. Recently, Barry Popkin (2008) reported that changes in our food system over the last 100 years have been devastating to our health. In addition, Carrera-Bastos (2011) reports that today's greater life expectancy is not due to a healthier diet and lifestyle; but to improved sanitation, vaccinations, antibiotics, better medical care and lower physical trauma.

The major reason for our greater life expectancy at birth is that modern medicine and improved sanitation have sharply reduced infant, maternal and childhood mortality. Our medical ability to keep older people alive, compared to the past, does not mean that people are healthier and living much longer. In fact, a comparison between US men who were 75 years old in 1999 and men who were 75 years old in 1900 reveals that the 1999 men only had a 1.5-year longer life expectancy. In view of the 40 versus 60-hour work-week, and the incredible increase in medical science and treatment, it appears that the 1999 males should have had a much higher life expectancy. Rollo (2010) also reports that as a result of industrialization, our consumption of animal products and calories increased sharply, and this trend reduced our health and longevity.

A world population of taller, bigger people increases the need for food, water, resources and energy (Cannon, 2013; Samaras, 2007). This increase is substantial, when one considers that the average weight of American males in 1900 was about 66 kg, compared to almost 90 kg today. Benjamin Alexander (Samaras, 1994) views our growth in body size as a potential disaster for future generations. Geoffrey Cannon (2013) also warned that our current trend to larger body size will consume more living and natural resources, which will make life harder for future generations. Waterlow stated (Cannon, 2013): "If everyone were to achieve the height now common in industrialized countries, the height explosion would be almost as disastrous as the population explosion, carrying with it the need not only for more food, but for more clothing, more space, more natural resources of all kinds." However, this paper does not deal with this area (Samaras and Storms, 2001), but focuses on the relationship between height and cardiovascular disease, cancer and longevity.

Last year, gerontologist Bartke (2012) reported that smaller size is an advantage, in terms of health and longevity. He pointed out that within the same species, smaller individuals live longer. Bartke and others report that smaller dogs, horses, rats, mice, cows and elephants (Asian versus African) live longer than bigger ones within their species. He also discusses human Laron dwarfs, in terms of their freedom from certain age-related diseases, such as cancer and diabetes. His paper also notes that a well-balanced, calorie-restricted (CR) diet reduces growth, but increases health and longevity among various animals. While historical demographers believe that increased body size is a reflection of improved nutrition and health, biologists take a different view and many are convinced that smaller body size promotes greater longevity (Gavrilova and Gavrilov, 2008). My research supports the view of biologists. The following material relates human body size to chronic diseases, longevity and caloric restriction (CR).

Original hypothesis for this research and data collection

The Second Law of Thermodynamics provided the initial impetus for this research into longevity. This law predicts that increasing disorder within a system is a function of mass and energy content. Application of this law to humans was based on interpreting disorder as aging, which was related to increased body mass and average daily energy consumption. Because height is an indicator of body mass, most studies involved searching for a correlation between height and longevity. Height was preferred, because weight can vary widely over a lifetime. Abundant research relating lower energy consumption with longevity was available since the 1930s and is generally considered the only known method for increasing human lifespan. Therefore, research into energy restriction was not emphasized.

We examined over 5000 papers, reports and books to determine whether a relationship exists between height, all-cause mortality, cardiovascular disease, cancer and longevity. Sources included retrospective, prospective, case-control, ecological and descriptive studies. We reviewed data from various parts of the world and included both developing and developed populations. Research and hypotheses dealing with biological factors that could explain the relationship among height, body weight and longevity were also examined.

Height and cardiovascular disease

Most studies find that taller people have lower cardiovascular disease (CVD) compared to shorter ones (Paajanen et al., 2010); however, many other studies find no correlation and some find shorter people have lower CVD. For example, within developing countries, shorter poorer people tend to have lower CVD than better off taller people. While Paajanen's (2010) paper is a well-done comprehensive review showing that taller people have lower CVD, it is based on correlation studies and does not prove causation. Tuomilehto (2010) reviewed Paajanen's paper and other findings, and concluded that short height is not biologically related to CVD. My study (Samaras, 2013) gives many examples of short populations with little or no CVD. If short height per se was related to CVD risk, then how can populations ranging from around 122 to 163 cm in height avoid it entirely? In addition, a dog study finds that the biggest dogs have a higher risk of heart failure, compared to smaller dogs (Samaras, 2013). For example, the Great Dane has 70 times the heart failure of the much smaller miniature Dachshund ($\leq$ 5 kg). In addition, the larger standard Dachshund (7–9 kg) has 3 times the risk as the miniature breed. The reasons for smaller people and animals having inherently lower CVD risk are described later, under "Biological explanations."

Height and cancer

The comprehensive WCRF/AICR (2007) report finds that there is "strong, consistent, and impressive" evidence that taller people have a higher cancer risk. The risk is not large, but subsequent reviews of cancer studies corroborate the 2007 report's findings. In addition, taller men suffer from most cancers at a higher frequency than women. A recent study found that men have a 55% increased risk of cancer, compared to women, and that 33.8% of the excess risk is related to their taller height (Walter et al., 2013). The researchers tracked 65,308 subjects whom were 50 to 76 years of age, for 2 years.

Height and longevity

Reports that taller people live longer generally reference mortality studies that follow a number of cohorts for a specific period and do not normally focus on the mortality of cohorts 70 years and older. Since 75% of people over 65 years of age die from CVD and cancer, this procedure misses critical data. In addition, mortality studies can suffer from a crossover problem. For example, a large study that tracked mortality beyond 85 years of age finds that below 70 years of age, tall (> 183 cm) men have the lowest mortality, but between 70 and 85 years of age, shorter men (from 170 to 183 cm) have the lowest mortality. Another potential problem is that compared to a > 70 year old cohort, younger men tend to die more often from non-chronic diseases, car accidents and other trauma, poisonings, infections and murder.

In contrast to most mortality investigations, longevity studies tend to look at older or deceased populations and almost all show that shorter men and women live longer. These studies concentrate on older ages or track the subjects until they die, through the entire adult age range of the cohort being studied. Earlier reviews (Samaras, 2009; Samaras and Elrick, 1999) provide a variety of evidence. A few examples follow:

1. Sardinia study: Salaris et al. (2012) looked at a population of elderly men in an isolated village, Villagrande Strisaili, in Sardinia. This village is known for its long-living people and their short stature (about 160 cm in their youth). It finds that shorter men within this relatively homogeneous population lived for about 2 years longer than taller men. This village is noted for having the highest percentage of centenarians in Sardinia, as well as all of Europe. Furthermore, Poulain et al. (2011) report that the male-female centenarian sex ratio is 1:1. This compares to a female advantage of 1:5 or more in many other populations.
2. Spanish study: A Spanish study tracked 1.3 million males from their youth to death. The shorter men had the best survival rates (Holzenberger et al., 1991). The lead researcher reports that the men lost 0.7 years per cm of increased height. Heights are based on military records and these men were tracked over a 70-year period.
3. Ohio study: A study of about 1700 deceased men and women living in Ohio finds that shorter people live longer (Miller, 1991). Miller found that men and women lost about 0.5 years per cm of increased height. Several unrelated studies also find a 0.5 year per cm reduction in longevity (Samaras and Elrick, 1999). In addition, Miller also finds that men and women of the same height have about the same longevity.
4. Elderly survival studies: A number of studies tracked elderly subjects to 70, 90 or 100 years of age. The survivors were shorter than those who died at earlier ages. For example, Rantanen et al. (2012) find that elderly male Japanese Hawaiians whom reached 100 years of age were almost 2 centimeters shorter than those whom died at 80 years of age. Another US study reports that the percentage of shorter people in the 90-year-old cohort is higher than an 85-year-old cohort (Samaras and Elrick, 1999). Shrinkage was not a factor, because people in the study were born during a declining height trend, between 1830 and 1890.
5. US ethnic groups: Based on US government death statistics, Asians have about one-half the all-cause death rate of whites and blacks (Eberhardt et al., 2001). Two intermediate groups, Latinos and Native Americans, were in between, in both height and mortality. The findings are based on data collected for the years 1985–1999 and represent about 18 million deaths over the 15-year reporting period. The height of each ethnic group tended to decline with declining mortality rates.
6. Male and female life expectancy and longevity: Women live longer than men. I found that in the US, men were 9% taller than women and had a 9% shorter life expectancy (Salaris et al., 2012). Men lost 0.52 years per cm of increased height, which is similar to several other populations studied, including Miller's findings, as previously discussed (Samaras, 2009). In an unpublished study, Boryslawski and Chmielewski (personal communication, April 2012) found that taller body height was related to a lower life span, for both sexes ($r = -0.2$; $p < 0.0001$). This study was based on > 700,000 deceased Polish men and women. It used the

heights from their youth. Their correlation coefficient was similar to that found in other studies; e.g. – 0.18 to – 0.33 (Samaras and Elrick, 1999).

7. Centenarians: Virtually all peer-reviewed centenarian studies show them to be short, after adjustment for shrinkage. Male centenarians usually vary from 156 to 165 cm. For example, Martinez et al. (2009) find that Cuban male centenarians average 156 cm. In a non-peer reviewed report on the internet, eight tall men (183 to 191 cm) lived for 100 or more years. Shorter women reach 100 years of age at a much higher rate than men, except in Villagrande Strisaili, where the ratio is 1:1. Gavrilova and Gavrilov (2008) found that US World War I (WWI) veterans of average height had the highest percentage of centenarians out of three groups: short, medium and tall. The actual heights of the three groups are not provided; however, US men in WWI averaged about 171 cm. Taller men were in second place. In spite of Gavrilova and Gavrilov's (2008) findings, almost all 20th and 21st century studies that I have found show male centenarians are substantially shorter than 171 cm; however, it is likely that more tall people will be reaching 100 years of age in the near future, due to modern medicine; e.g. the famous economist, John Kenneth Galbraith, was 203 cm tall and lived to 98 years of age.
8. Caloric restriction and longevity: Hundreds of studies find that CR is related to increased longevity in yeast, worms, insects, fish and rodents (Fontana, 2009). Reduced body size is also related to CR (Bartke, 2012). Studies on CR go back to the work first published in 1935 by McCay, Crowell and Maynard.

Most research deals with animals, but a few studies show that CR may increase longevity for humans; e.g. a number of people have been on CR for about 6 years, with good results in terms of the various risk factors for diabetes, CVD and cancer (Fontana, 2009). In addition, it is known that people in Biosphere 2 were on a CR diet and they had similar results.

Willcox et al. (2004) conducted a 36-year prospective study on over 1900 Japanese-American males, whom were 45–68 years old at the beginning of the study. Survival increased with decreasing caloric intake, down to 975 kcal/day. Below this lower value, mortality started increasing. When I computed height from the body mass index (BMI) and weight provided for each of five energy intake quintiles, there was also a decline in height with declining mortality, except when the energy intake dropped below 975 kcal/day (the minimum safe caloric intake for caucasians is higher than 975 kcal/day, because they tend to be taller and heavier than Japanese-Americans).

Traditionally, Okinawans follow a CR diet, compared to most other populations; e.g. Okinawan children in the past consumed about 40% fewer calories than those in mainland Japan and were shorter and lighter (Willcox et al., 2004). Adult Okinawans consume almost 20% fewer calories than the mainland. Okinawans are known for their long and active lives. They have the highest percentage of centenarians in the world.

Cuba is another example of what happens when energy is restricted. An economic crisis (1990–2000) resulted in much-reduced caloric intake, with health benefits: lower all-cause mortality, CVD and diabetes. Another CR example includes a group of urban Australian aborigines, whom were moved to a remote area. The aborigines followed the traditional hunting and gathering practices of their ancestors. Their caloric intake dropped to 1200 kcal/day. Virtually all risk factors for CVD and diabetes declined within 2 months.

Silva and Annamalai (2009) analyze the effects of CR on entropy and human longevity. Their analysis, based on the First and Second Laws of Thermodynamics, finds that an 18% reduction in caloric intake would increase human longevity by over 20 years, for both males and females. Reducing protein intake from 23% to 12% would increase longevity by 3.3 years. Their theoretical study is thus consistent with years of empirical evidence from animal research.

Biological explanations for the preceding findings

The following provides a variety of biological factors that support greater longevity for smaller humans. The material is based on comparing tall and short people of the same body types, because a short, overweight person is more likely to be less healthy than a tall, thin one. Note that BMI increases with increasing body height, when body proportions are maintained (Samaras, 2007). In addition, taller people tend to be heavier than shorter people. One study found a correlation coefficient of 0.79 between height and weight (Chen, 1990); however, differences in genetics, lifestyle, nutrition, medical care, BMI and economic status can modify these results, because height usually represents less than 10% of the longevity picture.

Reduced cell replication potential in old age

With some exceptions, we have a limited number of cell replications during our lifetimes. Taller people have more replications during their lives, because they need to create and maintain taller, larger bodies (Samaras, 2013). Thus, fewer cell replications are available in old age to maintain body tissues and organs. The telomeres (end section) on our chromosomes are biological markers indicating how many times cells have duplicated themselves. Maier et al. (Samaras, 2013) find that shorter 90-year olds have longer telomeres; therefore, more potential replications than taller people. Interestingly, male and female infants had the same number of potential cell doublings at birth, but male adults had substantially fewer. Stindl (2004) associates shorter male telomeres as being a major cause of differences in male-female longevity.

Increased DNA damage

Giovannelli et al. (2002) find that taller people have a much higher incidence of DNA damage than shorter people (Samaras, 2013). Thus, much of the aging process is related to DNA damage due to various stressors. Lifetime DNA damage increases the incidence of cancer and reduces longevity. Total daily energy expenditure also promotes DNA damage through heat generation and associated free radical generation.

Increased cancer risk due to more cells

A tall, heavier person has trillions more cells compared to a short, lighter person. These cells are subjected to internal and external stresses that damage the cells and promote cell replication, due to replacement needs. Thus, radiation, atmospheric pollutants, human and natural food toxins and higher free radical generation promote cell damage, which requires increased cell replication and thus reduces the potential for cell replacement in old age. In addition, with more cell damage and replication, the opportunity for DNA errors increases for taller people, along with the incidence of cancer risk previously described.

Heart problems

A variety of CVD problems are related to having a taller height. These include: higher blood pressure, greater left ventricular hypertrophy, increased work load on the heart, atrial fibrillation, blood clots and lower heart pumping efficiency (Samaras, 2013). The lower heart rate of taller people is considered a longevity advantage; however, centenarians are usually small with higher heart rates, which conflicts with the slow heart advantage. In addition, small dogs have much higher heart rates compared to big ones, but they also have a small fraction of the heart failure that big dogs have (Samaras, 2013).

A larger left ventricular mass (LVM) is related to increased all-cause mortality, CVD and stroke, independent of other risk factors (Bouzas et al., 2012). Rider et al. (2009) report that LVM is positively correlated with increasing height, weight, fat mass and BMI. This finding is consistent with the much lower death rate from heart failure for small dogs versus big dogs that was previously discussed.

During the first year of life, the heart grows by increasing the number of cells. After that period, it grows through cell enlargement. For bigger people, the cells have to enlarge by a greater amount to create a larger heart. The laws of scaling indicate that bigger cells have lower surface area in comparison to their mass (Samaras, 2007). Thus, the exchange of energy, nutrients and waste is slower in a larger cell, because mass is related to consumption and waste products. How much of an effect this would have on health and longevity is not known; however, over a lifetime it could be significant.

High protein intake

Protein is a key factor in promoting greater height growth (Campbell and Campbell, 2006; Hoppe et al., 2004). The minimum level of protein is 0.7 to 0.8 gr/kg of body weight; however, requirements vary depending on one's muscle mass and physical activity levels.

The high intake of protein in the developed world reflects our greater stature. Hoppe et al. (2004) find that total caloric intake, total protein intake and the percentage of energy from protein are tied to taller height in children. Unfortunately, protein also produces a variety of waste products (urea, creatinine, uric acid and hippuric acid) and increases free radical generation at a higher rate than carbohydrates and fats (Lopez and Barja, 2008). A high animal protein diet also increases chronic diseases (Campbell and Chen, 1994). Protein is associated with higher levels of fibrinogen, lipoprotein(a), C-reactive protein and insulin-like growth factor 1 (IGF-1) (Fleming, 2000; Hoppe et al., 2004). These substances are related to increased CVD and cancer. High animal protein is also tied to higher levels of Apolipoprotein B, which is associated with heart problems. In addition, strong evidence indicates that red meat and processed meats increase the all-cause mortality and various chronic diseases (Campbell and Campbell, 2006; Tufts, 2009).

While the consensus supports reduced red and processed meat consumption, a paradox exists. The diets of many traditional societies of hunter-gatherers and nomads include a substantial percentage of unprocessed animal products, yet these populations are relatively free of CVD. These include the Maasi, Hadza and pygmy people. There are a few possible explanations for their low CVD. The total calories consumed by hunter-gatherers and nomads are low and any negative impact of the animal protein consumed is offset by a sparse diet, as is evident by their lower height and weight. Another factor is a genetic adaptation to a diet consisting mainly of meat and milk (Maasi). A third factor is that wild animal protein is free of the chemicals found in animal products produced by developed countries. Wild animals also tend to be very low in fat content. Because we don't have studies showing that these people live to old ages, we don't know if their low CVD would last, if they had the medical care that allowed them to reach advanced ages; however, there are many populations whom consume a plant-based diet whom have low CVD and reach advanced years; e.g. in Okinawa, Japan; Ikaria, Greece; Bama, China; and Loma Linda, CA in the US.

Lopez and Barja (2008) find that lowering the protein in an isocaloric diet increases maximum longevity in rodents, through reduced free-radical generation. In contrast, the relative increase in carbohydrates and fat did not increase production of free radicals, compared to greater protein intake. They report that the mean intake of protein in Western populations is much higher than required and that lowering protein intake while maintaining calories constant would reduce tissue damage from free radicals and increase humans' lifespan.

A certain amount of protein is essential for childhood growth and good health, but our success in producing bigger humans at an earlier age has a price, in terms of increased chronic diseases and reduced longevity. Feeding children so that they grow slower and reach maturity at a later age might not reduce height very much, but their risk of overweight or obesity would be substantially lower.

Rapid childhood growth

Singhal et al. (2003) report that growth acceleration correlates with long-term health problems in humans and animals. In addition, a systematic review by Monteiro and Victora (2005) finds that most studies show a positive association between rapid growth (height or weight, or both) and increased overweight and obesity, regardless of age. They also report that catch-up growth is widely found to be related to chronic disease, including heart disease. In addition, Freedman et al. (2002) find that tall children are at 5 times the risk of becoming obese adults than their shorter-than-average peers. Several other researchers find there is a relationship between a rapid growth in height and adult obesity.

Hong et al. (2010) recently reported that small for gestational age (SGA) Chinese children whom experienced height catch-up growth had lower levels of adiponectin and higher insulin resistance (IR): both are undesirable conditions, as lower levels of adiponectin reduce health and longevity (Bartke, 2012). Higher levels of IR are related to poorer health, due to diabetes. The degree of increased IR and reduced adiponectin levels are related to current BMI and the increase in height of SGA children. Shorter SGA children, who did not experience height nor BMI catch-up growth, had higher levels of adiponectin and lower IR, when compared to the average for gestational age children of normal height.

Rollo (2007) reports that slow and protracted growth could increase our longevity by a substantial amount. Frame et al. (1998) also conclude that abundant nutrition, rapid growth and early sexual maturity reduce longevity. In addition, Jacobsen et al. (2007) find that women whom experienced menarche before 11 years of age have a 20% higher all-cause mortality, compared to those whom reached menarche at 17 years of age. Santos et al. (2008) find that women whom had menarche before or at 12 years of age have a higher risk of metabolic syndrome (MBS), compared to those whom had menarche after 14 years of age. In addition, they find that height has no impact on MBS for women, but shorter men have a lower risk of MBS when compared to taller men. Although the differences are not statistically significant, they represent more than a 40% higher MBS risk for both findings.

IGF-1, insulin levels and growth hormone

Preliminary data indicate that long-lived people have lower IGF-1 and higher insulin sensitivity (Van Heemst et al., 2010). Bartke (2012) also reports that genetically lower growth hormone, which reduces IGF-1 levels, reduces human growth; and individuals with growth hormone deficiency are virtually free from cancer and diabetes. In addition, Rollo (2007) reports that very long-lived people tend to have relatively low IGF-1 and higher insulin sensitivity; however, very low levels of IGF-1 can be related to increased heart problems.

Switzer et al. (2009) find that there is a strong correlation between IGF-1 and height, weight and protein catabolism. Hoppe et al. (2004) also report that IGF-1 levels correlate with height, weight and BMI. Other data (Ong et al., 2005) also show that higher insulin levels and lower insulin sensitivity are associated with greater height and weight at 8 years of age. Sinaiko et al. (1999) report that greater height at 8 years of age correlates with higher insulin levels at 24 years of age.

Lower SHBG and IGFBP-1

Lower levels of sex hormone binding globulin (SHBG) are related to all-cause, cancer and CVD mortality. Studies find that greater height is correlated with lower SHBG (Chen et al. 1990; Lonning et al. 1995). SHBG also declines with increasing insulin and IGF-1: both of these factors are related to greater height and larger body size. In contrast, higher levels of IGF binding protein-1 (IGFBP-1) are related to increased SHBG. Also, IGFBP-1 tends to be higher in smaller individuals with lower weight and lower BMI (Wolk et al., 2004). For all age groups of men, there was a non-significant negative correlation between height and IGFBP-1, but the correlation was only significant for men whom were 65–76 years of age.

Relatively smaller organ size

The hearts and lungs of taller and shorter people are proportional to their body masses; however, for taller people, other organs such as brain, liver and kidneys are smaller in proportion to their body mass (Samaras, 2007). Thus, most of the organs of taller people have a smaller functional capacity in relation to their body weight. While the difference is not large, over a lifetime, as cell and DNA damage accumulate, shorter people have a greater cell reserve going into older ages.

How do these findings affect taller people?

Viewing these findings requires the same perspective that we have when men are told that women outlive them. Yes, women live about 5 to 7 years longer than men; however, many men outlive the average woman. The same rule applies to taller and shorter men and women. Shorter people have a potential advantage, but many taller individuals outlive the average short person.

As mentioned, taller individuals usually have a number of health advantages, due to their higher income and living standards. Most studies show that higher income people have substantially lower mortality from CVD and all causes, compared to poor people. In contrast, longevity studies indicate that shorter people live longer. However, taller people can offset negative factors by following modern nutritional and lifestyle advice, such as by avoiding overweight, obesity and smoking; and by eating a plant-based diet high in fiber, but low in salt, sugar and saturated fat. Of course, regular exercise and a network of good friends are also positive factors. As mentioned, tall men can reach 100 years of age. With advances in medicine, we will be seeing many more tall centenarians than in the past; however, it is not wise for a taller person to uncritically accept the findings of mortality studies that they will live longer, simply because they are taller.

What are our public health choices?

The proponents of taller, bigger people support their position by stating that taller height is desirable, because it is consistent with the genes that nature gave us; however, if this is a valid observation, then we could justify weighing 140 kg simply because we have the genetic potential to achieve this weight. I don't think too many people would agree that the average human should weigh 140 kg.

Unfortunately, we don't have enough facts to specify the best height for humans: The optimum height and weight need to be determined by further research, but the findings presented in this paper point toward smaller humans than now exist in the developed world.

In view of the findings presented in this paper, what should medical and public health experts do? Making people shorter is not a popular idea; however, nutrition and public health groups should certainly de-emphasize the view that a taller height is necessary for good health and success in life. After all, the present height bias hurts over one-half the population within a country. We should not continue hurting our friends and relatives whom are shorter than average. In addition, should nutritionists and public health experts promote male growth to an average height of 185 cm, as has occurred in the Netherlands? Are the artificial social benefits worth the costs to human health, non-human life forms, the environment and human survival?

While this paper did not focus on the resource and environmental ramifications of increasing human body size, public health considerations have to recognize that from an ecological viewpoint, slim, small people eat less food and consume fewer natural resources (Cannon, 2003). By preserving our environment and reducing global warming, the public is more likely to avoid the spread of infectious diseases. In addition, the MIT engineering professors Hansen and Holley Jr. report that smaller people would be equivalent to increasing the size of the earth and all its features, and this human size reduction would not be difficult to attain (Samaras, 1994).

I'm sure future medical developments will allow widespread creation of taller people through genetic engineering. When this happens, what will be the ideal height? If every male becomes 188 cm tall, this will become the new average and it seems reasonable to expect that our height bias will favor this height until parents in the future are motivated to create children that average 193 cm. Then a new optimum height is likely to be established, until the next generation establishes a new ideal height. Obviously, this pattern could continue for many generations, resulting in very large people and greater demand for food, water, energy and resources. I believe that we should make a choice now, to stop the progressive increase in our children's height and weight. We can do this by following healthful practices that are now agreed to by most authorities, with emphasis on a plant-based diet, minimal caloric and protein intake for good health, and weight control. Belief in rapid childhood growth, early sexual maturation and reaching one's genetic potential for height should be left in the past.

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