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Review Article

Shorter height is related to lower cardiovascular disease risk – A narrative review

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ABSTRACT

Numerous Western studies have shown a negative correlation between height and cardiovascular disease. However, these correlations do not prove causation. This review provides a variety of studies showing short people have little to no cardiovascular disease. When shorter people are compared to taller people, a number of biological mechanisms evolve favoring shorter people, including reduced telomere shortening, lower atrial fibrillation, higher heart pumping efficiency, lower DNA damage, lower risk of blood clots, lower left ventricular hypertrophy and superior blood parameters. The causes of increased heart disease among shorter people in the developed world are related to lower income, excessive weight, poor diet, lifestyle factors, catch-up growth, childhood illness and poor environmental conditions. For short people in developed countries, the data indicate that a plant-based diet, leanness and regular exercise can substantially reduce the risk of cardiovascular disease.

1. Introduction

In 2010, a meta-analysis of 52 studies found that short people had higher rates of coronary heart disease (CHD).[1] The negative correlation between height and CHD is basically correct. However, this correlation does not prove that short height promotes CHD per se and some researchers have attributed the findings to other factors. For example, Tuomilehto[2] evaluated the Paajanen study[1] and concluded that there are too many conflicting findings to conclude that short height is biologically related to CHD. He points to several paradoxes; e.g., between 1900 and 1970, CHD in Finland increased in parallel with increasing height. Also, in most populations, women are shorter than men and have lower CHD. In addition, Wells[3] reported that cardiovascular disease (CVD) has increased in parallel with increasing height during the 20th century. Furthermore, the World Cancer Research Fund and American Institute of Cancer Research[4] found that the Western diet promotes increased height and CVD, stroke and other chronic diseases. In addition, Tuomilehto[2] and Silventoinen[5] reported that the Western diet was correlated with both greater height and CVD.

The following provides a counter view to the Paajanen findings[1] including a variety of examples from international studies showing that shorter people have lower incidence of CVD. In addition, the biological mechanisms for this low incidence of CVD are reviewed. The information provided is not widely known among the medical profession and provides a fresh view of CVD risk in relation to body height.

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2. Methods

The PubMed database was searched using MeSH terms: body height and coronary disease/mortality and cardiovascular disease/mortality. Papers were evaluated for findings related to lower coronary and cardiovascular mortality. In addition, a file of over 5000 papers, reports and books was searched for populations with low coronary and cardiovascular mortality. These papers were collected over 37 years as a part of research related to health, longevity, and other factors related to the ramifications of smaller human and animal body size.

3. Results

During the 20th century, numerous studies found that short populations in traditional societies have little to no CVD. A sampling of examples showing shorter people have low CVD mortality are included in this section. This section concludes with the biological advantages of shorter height in relation to CVD.

3.1. *Neutral findings*

A number of studies indicate that neither tall nor short people have increased risk of CVD. These neutral studies were based on United Kingdom, South Korean, international, and US cohorts (Hosegood and Campbell,[6] Kannam,[7] Samaras,[8] Song and Sung,[9] Song,[10] and Liao[11]). A number of other studies have also failed to find a significant correlation between height and CVD.[12]

3.2. *Findings showing shorter people have lower CVD mortality or risk factors*

Table 1 provides examples showing shorter people have low or no CHD or stroke. Table 1 consists of longitudinal, cross-sectional, ecological and descriptive studies. In addition, the examples include a variety of ethnic groups, geographical locations and diets. A few examples, such as the Solomon Islanders, US California ethnic groups, Belfast vs. Toulouse, and the island of Kitava are summarized next.

3.2.1. *Absence of CVD in the Solomon Islands*

Page[21] evaluated the CVD risk factors of 1390 adults in six different Solomon Island societies. The physical health and nutrition of these societies were good and no clinical evidence of CHD and atherosclerosis was found. Males 20 years and older averaged 161 cm and 58.8 kg. Their average BMI was 22.7 kg/m^2. Physical fitness was excellent based on their ability to carry heavy loads uphill for many miles.

3.2.2. *Lower CHD among shorter Californians and Western Europeans*

A study of 1 million deceased Californians found that the shortest ethnic groups (Chinese and Japanese) had substantially lower risk of CHD mortality than the tallest (Blacks and Whites).[12] Latinos and Asian Indians were in between these two groups in terms of height and CHD. These data were compared with eleven Western European countries. While the ethnicities differed, the pattern of reduced CHD mortality with reduced height was basically the same; e.g., the taller N. European males had higher CHD mortality vs. shorter S. European males. Mortality rates for the tallest Californians (Whites and Blacks) and Scandinavians were roughly the same as were the rates for the Chinese and Japanese in California vs. the Spanish and Portuguese in Europe. The tallest men in California and N. Europe were about the same height as were the heights of the shorter Japanese, Chinese, Spanish and Portuguese.

3.2.3. *CVD comparison between Belfast and Toulouse*

The CHD and stroke mortality rates between 400 men in Belfast, N. Ireland and 400 men in Toulouse, France were evaluated[22] for males 45–54 years of age. CHD was 4 times higher in taller Belfast males vs. shorter Toulouse males. Stroke was up to 2.1 times higher in Belfast males. Belfast males were 173.3 cm and 78.9 kg vs. 171.1 cm and 76.4 kg for Toulouse males (personal correspondence, E. McCrum, PhD, unpublished data, 5/11/2000).

3.2.4. *Absence of CHD and stroke in Kitava*

Lindeberg[23] evaluated the cardiovascular risk factors in a well-nourished traditional Melanesian population located on the island of Kitava. The study included 151 males and 69 females aged 14–87 years, and the population was essentially free of Western dietary habits. This 10-year study found no evidence of stroke and CHD based on interviews, clinical experience, and resting electrocardiography. About 80% of the adults smoked and were moderately active (activity levels were about the same level of comparable Swedish cohorts). Kitava males averaged ~161 cm from 20 to 86 years and females averaged 150 cm. Male body mass indexes (BMIs) fell from 22 to 19 with increasing age while female BMIs declined from 20 to 17 with increasing age. These findings are consistent with previous studies that found no CHD or atherothrombotic stroke in all of Papua New Guinea.[24] These findings covered a 70-year period and were based on clinical investigations and autopsy studies.

3.2.5. *Support from centenarian and canine studies*

Most studies find that centenarians are usually short and lean even when adjusted for shrinkage with age.[15] It is doubtful that many people can reach 100 years of age with bad hearts. For example, an area in Sardinia made up of 14 municipalities is identified as the Blue Zone and has the highest longevity in Sardinia and mainland Italy (Poulain,[13] Salaris[25]). The people in the Blue Zone are the shortest and also have the lowest CVD mortality in Sardinia.[13] Longevity was also found to increase with decreasing height. In summary, short Blue Zone males had the best long-term survival rates and the lowest CVD mortality in Sardinia. A recent study based on Western Sicilians also found that centenarians were short and free of cardiac risk factors and heart disease.

A large Canine study supports human findings. It was found that shorter and smaller dogs have lower heart failure than medium and large dogs.[26] Based on 350,000 dogs, short dogs had 1/60 the heart failure rate of tall dogs. Miller and Austad[27] provided similar findings.

Table 1 – Examples of short populations with low cardiovascular disease.

Example	Remarks	Reference
Shortest people in Sardinia had the lowest CVD mortality	Based on 14 municipalities	13
Swedish study found men ≥191 cm had twice the mortality from CVD and respiratory disorders vs. men ≤170 cm		14
Six shorter populations had less than half the CHD mortality vs. six tallest Western European countries	Both sexes Based on millions of deaths	15
China's CHD death rate was 1/10 that of taller North America and Australia	Later part of 20th C	8
Guangzhou (Canton) had the lowest CHD in the world	Later part of 20th C Males: 164 cm	8
S. European CHD rates were 1/3–1/2 the rates of taller N. Europeans		8
S. Italians have lower CHD death rates compared to taller N. Italians		8
Shorter rural blacks in S. Africa have low CHD vs. taller White population		8
The short Sami (Lapps) have exceptionally low CHD compared to the taller general population		8
Among low income US adults, the shortest have 39% lower risk of heart disease vs. tallest adults		16
Shorter men in Ushibuka, Japan had much lower death rates from CHD and stroke vs. the taller Tanushimaru Japanese		8
Shorter Native Americans have lower CVD mortality vs. taller Native Americans		17
Six European countries with lowest CHD were shorter than the six tallest countries in Western Europe		17
California Japanese and Chinese had ∼1/2 the CHD mortality of taller Whites and Blacks	1/4 million deaths for six ethnic groups. Both sexes	18
California Latinos and Asian Indians had much lower CHD mortality vs. taller Whites & Blacks		17
Shortest US ethnic groups have the lowest CHD mortality	Millions of deaths. Five ethnic groups	17
CHD was rare before urbanization	People were taller after urbanization	17
Shorter Okinawan males had 1/4 the CHD mortality of taller mainland Japanese and 1/6 the mortality of taller US males		17
Many short populations with little or no CHD and stroke; e.g., Solomon and Cook islands, Congo pygmies, Papua New Guinea, Tarahumara Indians, Yanomamo Indians, Fiji islands	Height range: less than 152–<165 cm Data based on mid-20th C	17
Based on 16 populations, shorter men showed a lower CHD mortality trend	Mid-20th century	18
Shorter Toulouse (France) had 1/4 the CHD mortality of taller Belfast (Ireland) males		18
Taller Hindu males in India had much higher CHD incidence and hypertension vs. shorter Muslim males in India	Lower differences between females	18
Shorter native Japanese had lower CHD mortality vs. taller Hawaiian Japanese, and taller California Japanese had higher CHD vs. shorter Hawaiian Japanese		18
Shorter Chinese had lower CHD mortality vs. taller Chinese	Joint Chinese, US, & UK study	18,19
No evidence of CHD or stroke in Kitava (males: 162.6 cm), an island off Papua New Guinea	Subjects 14–87 years of age	18
Taller affluent Pakistanis had 3 times the incidence of CHD vs. shorter poor people		
Shorter women have substantially lower CHD mortality throughout the world		18
A longitudinal study found the risk of CHD in adulthood was lower for adults who were short at 11 years vs. those who were tall		18
Shorter US Blacks had much lower heart disease vs. taller Whites before the 1930s.		15
WWI tall recruits had more heart disorders than shorter recruits	Based on 1 million recruits	8
Taller US men had a higher CHD mortality vs. shorter men		20

3.3. Biological advantages of shorter height

A number of biological factors indicate that shorter, smaller bodies have an inherently lower risk of CVD. These factors are based on the assumption that tall and short people are of similar body types.

3.3.1. Lower BP

Blood pressure (BP) tends to increase with greater height, body weight and BMI. A large US study found height was the strongest factor affecting BP throughout childhood and adolescence.[28] Weight was also a strong factor. In addition, adult BP was reported to correlate with BP in childhood, adolescence and young adulthood. Thus, shorter, leaner people are less likely to have elevated BP and are at lower risk for CVD and stroke.

3.3.2. Lower workload per stroke

The hearts of shorter people are scaled to their body weight. Thus, they have to pump an amount of blood in proportion to their body volume. However, shorter people have an advantage that their hearts do not have to pump blood as high as the hearts of taller people. Taller people's hearts have to work harder in accordance with scaling laws[29]; e.g., a 10% taller person of the same body proportions as a shorter person has to pump 33% more blood 10% farther. Yet, the heart's maximum muscle strength is only 21% greater. Shorter people, however, have a higher resting pulse rate. This may not be a problem since small dogs, with their higher pulse rates, have very low heart failure risk vs. larger dogs.[26]

3.3.3. Lower venous thromboembolism

In developed countries, venous thromboembolism (VTE) is the third most common CVD illness. Shorter males were found to have substantially lower VTE in a large Norwegian study.[30] A cohort of 26,727 subjects aged 25–96 years was tracked over a 12.5 year period. Men in the upper height quartile (>181 cm) had twice the risk of VTE compared to the shortest quartile (<173 cm). However, tall (>167 cm) women did not have a significant trend.

3.3.4. Lower left ventricular hypertrophy

Left ventricular hypertrophy (LVH) occurs when the heart's wall thickness increases without a corresponding increase in heart volume. This condition increases the risk of CVD morbidity and mortality.[31] Based on a study of 4976 men and women, Levy[31] found a significant trend toward greater rates of LVH in taller men and women without adjusting for body size. After adjusting for body size, a sharp increase in LVH occurred with rising BMI, starting from <22 kg/m^2 for men and <20 kg/m^2 for women; e.g., a 2 kg/m^2 increase in BMI was found to increase the prevalence of LVH by 47% in men and 51% in women.

Another possible advantage of a smaller heart is the smaller size of myocytes. After the first year of life, increased heart size occurs through cell enlargement rather than cell replication. According to the laws of scaling,[22] cell mass increases at a faster rate than its surface area. As a result, the supply of nutrients and oxygen through the cell membrane (surface area) would be less than the mass being fed. In addition, removal of waste products and heat energy would be similarly less efficient.

3.3.5. Lower atrial fibrillation

Atrial fibrillation (AF) involves an irregular heart beat pattern that is correlated with increased risk of heart failure and stroke. Hanna[32] evaluated 25,268 patients with impaired left ventricular dysfunction. They found that AF increased linearly with increasing height. There was a 32% increase between short and tall subjects with a $p < 0.0001$. Height is correlated with left atrial (LA) size and is the strongest independent predictor of AF. Taller height also correlated with AF independent of other risk factors.

3.3.6. Greater cell replicative capacity and longer telomeres reduce CHD

Within a species, the remaining capacity of cells to reproduce is tied to chronological age.[33] Maier found that shorter elderly people had greater cell replicative capacity compared to taller people. This reduced capacity of taller people is due to a higher number of cell doublings during the growth period and greater cell replacement and maintenance over the adult lifespan. In addition, larger men had a lower replicative capacity compared to women although men and women had the same replication potential at birth.

Telomeres tie the ends of chromosomes together. When cells replicate, telomeres get shorter and their lengths are markers for the number of future cell replications possible. A number of studies have found that aging of the cardiovascular system is connected to telomere shortening.[34] In addition, Brouilette[35] found that shorter telomeres almost doubled the risk of CHD compared to the longest telomeres.

3.3.7. Lower DNA damage

Giovannelli[36] found that taller men had much higher DNA oxidative damage than shorter men ($p = 0.02$). The shortest men and women had a damage level of 3.28% vs. 6.08% for the tallest people. Less damage to the DNA of the heart muscle cells during one's lifetime may help maintain heart-pumping capability.[37–39] In addition, with slower childhood growth, resources are less likely to be diverted in favor of rapid growth and taller stature, resulting in improved repair of DNA and other cellular components.

3.3.8. Higher pumping efficiency

Higher heart pumping efficiency increases the supply of oxygen and nutrients per kilogram of body mass. Smaller hearts have a higher pumping efficiency compared to larger hearts.[40] De Simone found that heart size correlates with height, and taller people have a lower pumping efficiency. For normotensive adults, stroke volume and cardiac output increased at a lower rate with increase in height than with increase in weight (in proportion to the power of 0.71). Thus, both stroke volume and cardiac output do not keep up with body size of a taller person.

3.3.9. Lower cystatin C, lower creatinine and higher SHBG

Knight[41] reported that cystatin C and creatinine levels correlate with height and weight. However, higher levels of cystatin C and creatinine are associated with greater CVD risk factors.

Chen[19] found that Sex Hormone Binding Globulin (SHBG) decreases with increasing height. In addition, their findings indicate that lower SHBG levels are correlated with increased mortality from stroke, hypertensive heart disease, myocardial infarction and coronary heart disease.

3.3.10. *Shorter people have lower BMIs, cholesterol, triglycerides, and higher HDL*

If short and tall people of the same body proportions are compared, the taller people will have higher BMIs based on empirical evidence and the laws of scaling.[29] For example, if we compare a 10% taller person to a shorter person, the BMI will be 10% greater than that of the shorter person with the same body proportions.

Lamon-Fava[42] found that biological parameters related to CHD became worse with increasing BMI from below 21 to a BMI over 30. Changes in these parameters were age adjusted and increased linearly in middle-aged nonsmoking men and women. They found that as BMI increased, systolic blood pressure, cholesterol, triglycerides, glucose, and low-density lipoprotein increased while desirable levels of HDL and Apo A-1 decreased. Hypertension, type 2 diabetes and Apo B also increased. Mendall[20] also found C-reactive protein increased with both height and BMI. All these factors have been related to increased risk of CVD.

3.3.11. *Heart advantages of taller people*

Taller people have a few heart advantages. Taller people have a lower resting heart rate compared to shorter people. A lower heart rate is generally associated with a longer functioning heart. In addition, larger diameter arteries are less likely to develop plaque build up on the Western diet. However, the previous discussion of Solomon and Kitava islanders indicates that if these are desirable factors, other aspects of being small offset the disadvantages of a higher heart rate and smaller blood vessels.

4. Discussion

In view of substantial contrary findings on height and CVD, why are there such strong differences among studies? Tuomilehto[2] pointed out that short stature is tied to lower socioeconomic status (SES) and lower SES is related to increased CHD. Since it is not short height per se that explains why shorter people in developed countries have more CVD, environmental and lifestyle factors must be the cause. These include differences in SES status, nutrition, medical care, lifestyle practices (smoking, lack of exercise, excessive drinking), and catch-up growth of low birth weight infants. Singhal,[43] Monteiro and Victora[44] and Bartke[45] have reported that low birth weight children that are overfed to accelerate their growth (catch-up growth) experience increased risk of heart disease and other chronic diseases. It should be noted that this catch-up growth does not normally result in low birth weight children catching up to the height of their adult peers who were of normal birth weight. Lower SES adults also tend to be shorter, more obese and less healthy compared to higher SES people.

Evaluation of CVD among short individuals needs to consider the following.

1. SES risk factors over three phases of life.[46–48] Evaluating only one or two SES phases can provide misleading results.
2. The role of dietary factors; e.g., during the lean years of WW II, Europeans experienced a drastic reduction in CVD.[49]
3. Incorrect association of short height with adult disease when the shorter height is due to childhood disease; e.g., ~50% of short children suffer from pathological conditions and childhood illnesses increase the risk of adult chronic disease.
4. Are tall and short people with the same body types being compared?[29]

5. Conclusions

The findings of this paper indicate that shorter height appears to be an advantage for avoiding CVD under traditional lifestyles. This finding is consistent with Bartke's gerontological review that smaller body size is related to greater longevity.[50] However, short people following a Western diet and poor health habits are at increased risk due to high fat, calorie diets and excessive weight. Promoting catch-up growth or taller stature during childhood also increases risk. Therefore, shorter people need to focus on keeping lean and following a healthful lifestyle and a plant-based diet.

Conflicts of interest

The author has none to declare.

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