Our Changing Bodies: The lessons of anthropometric history

Professor Sir Roderick Floud

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In its infinite variety, the human body has been a source of endless fascination throughout the ages. We are all individually conscious of our own appearance and that of others; that individuality serves as a means of recognition and of differentiation.

But individuality can sometimes obscure regularity. Today I want to discuss not individual but collective aspects of the human body. I will describe how our bodies have changed in past generations and how such changes help us to understand our societies and economies. I will argue that those changes are a key to understanding economic growth since the eighteenth century and that they offer hope for further improvements in human health and welfare.

Because I will be discussing groups of people, rather than individuals, I will be discussing averages, remembering always that behind every average is a distribution of individuals. What do I mean by this? As an example, the heights of a group of people - even as small a group as the audience here today - are approximated by the normal distribution, with some very tall, some very short, but most clustered towards the middle or average height of the group. Other characteristics - such as income or wealth, longevity or strength - are distributed among us in other ways; we are all single observations within a myriad of distributions, even though we are usually not conscious of this fact.

What, first, are the most obvious changes that have occurred in the shape of the human body in recent centuries? Television costume dramas are notable for their attention to detail, to the most minute aspects of costume or furnishings. But there is one aspect of the past which, unavoidably, they get wrong. The actors are too tall and, usually, too fat, properly to portray historical characters. We know this because, over the last thirty years, I and my colleagues in the discipline now known as anthropometric history have collected enormous amounts of information about the heights and, where available, the weights of people in past societies. This has enabled us to map, in time and space, changes to average height and sometimes to average weight and body mass, in many societies at many different stages of economic development. This evidence can easily be compared with the position today because we know that, in all societies, human growth follows a common pattern, most easily shown on the growth charts against which all modern babies are monitored.

Our best evidence relates to the heights of adult males. Over two centuries, the average height of males in the UK rose by 9 cm or 3.5 inches. The Dutch, now the tallest nation in the world, grew by over 4 inches. The Norwegians, the second tallest, grew by much more, perhaps 20 cm or about 8 inches.

One difficulty in discussing these changes is that they seem to be small, only a few inches or centimetres. In reality, they are large, for three main reasons. The first is that we are extremely good at assessing the heights of other people, whether individually or in groups, and that we can perceive differences which are only of a few centimetres; if any of you have visited China or the Netherlands, you will probably have felt tall in the former, short in the latter. The second reason is that height is extraordinarily sensitive to a variety of influences which I will discuss, so that apparently very small differences can be both actually and statistically significant. And the third reason is that we are observing changes to averages, to summary measures of underlying distributions of changes which have occurred to very large numbers of people.

The fact that we are taller than our ancestors is well-known. Less well-known, but well-documented in recent years, is that the growth in average height has been neither uniform nor continuous. There have been periods, for example in the middle of the nineteenth century in a number of European countries,

including the UK, and in the United States, when the average height of the population actually fell; there have been other periods in which heights remained stable for some years, others in which there was rapid growth. Nor has growth been uniform within countries; regions such as the south-east of the UK were relatively short areas at the start of the 19th century, while the Scots and even the Irish were relatively tall - now that position is reversed. Moreover, if one reaches further back into the past by the use of skeletal material, heights appear to have been greater among a number of hunter-gatherer societies than among the more settled farming communities which immediately succeeded them.

As height has increased, so too has weight, although not at the same time or at the same rate; in the late nineteenth century, gains in average height were not matched by similar gains in weight, so average body mass may have declined. Obesity is not a new phenomenon but in recent years, as everyone knows, weight has increased faster than height; developed countries have seen a so-called epidemic of obesity, with larger and larger proportions of populations being described, somewhat arbitrarily, as overweight or obese.

Are these changes in height and weight merely curiosities or do they tell us something of interest? There is increasing evidence that they do, particularly when combined with other evidence of our changing bodies. One such change is in how long we live. World life expectancy has more than doubled over the past two centuries, from roughly 25 years to about 65 for men and 70 for women. Before 1950, most of the gain in life expectancy was due to large reductions in death rates at younger ages. In the second half of the 20th century, improvements in survival after the age of 65 were the driving force. Most remarkably, female life expectancy in whichever was at the time the longest-lived country has risen for 160 years at a steady pace of almost 3 months per year, an increase of 40 years life expectancy in 160 years; and there is no sign that this growth is slowing. All of us in this room have benefitted from this rise in life expectancy, but our children and grandchildren will probably benefit even more; it is confidently predicted that half of all today's twenty-year-olds will live to a hundred or more.

Less well known than the rise in life expectancy is the improvement in years of health, sometimes measured as years of healthy life. This improvement is, indeed, sometimes denied; it is suggested that enhanced life expectancy will be a burden on society, because health services will have to cope with many more years of ill-health, as well as having to pay pensions for extended periods. Historical evidence does not support this pessimistic view. Firstly, the population is much less prone to diseases or injuries which, in the past, crippled many early in their lives. Hernia rates at ages 35-39, for example, were more than three times as high in the 1860s as in the 1980s and chronic diseases were much more prevalent later in life. Second, the average age of onset of many life-threatening diseases has risen along with the age of death. So, our expectation of years of healthy life has risen with our life expectancy. This should offer hope to those who forecast an impending health and pensions crisis, although it may be less well received by future generations; they will be healthy enough to work for more years than is expected today and may have to do so.

So, we are taller, heavier, healthier and longer lived than our ancestors; our bodies are sturdier, less susceptible to disease in early life and slower to wear out. Moreover, there are very few areas of the world where these bodily changes have not occurred. One sign of this is the improvement in sporting achievement, as world records are regularly broken and not only by those who have taken performance-enhancing drugs. In many sports, the growth in the physical size and strength of athletes has outgrown the equipment and rules which were devised for shorter people.

But why has all this happened and is there any connection between all these different changes which have occurred to the human body? I want to suggest some possible causes for these phenomena and then link them together.

To cut a long story short, there is now a consensus that anthropometry, demography and the other disciplines concerned with our changing bodies are all measuring aspects of what human biologists call 'nutritional status'. This term denotes the balance between the inputs into the human body - in the form of food, warmth, even love - and the outputs in the form of body maintenance, body growth, the combating of disease and the energy requirements of work and play. We are taller and heavier than our ancestors because the balance between inputs and outputs is more favourable than it was in the past. Moreover, it is increasingly clear that what is of particular importance is our nutritional status during our early years of growth, even within the womb.

Anthropometry thus provides an excellent means of measuring improvements in welfare or living standards in the past. Height and other anthropometric statistics are measuring not just income, not just food intake, not just disease, not just the quality of parental care, not just the amount of work we do or the exercise we take, but an amalgam of all of these. Many of our body measurements are determined very early in life. Measurements of height, for example, reflect the position of individuals and groups during early life, particularly before the age of two, when we are already set on our growth pattern. But it is now clear that the measurements also indicate what may happen to us and to the groups of which we are a part throughout the rest of our lives. Wait a minute, I can hear you saying. Is he suggesting that food and health before and immediately after birth can affect us for the rest of our lives, even affecting how long we live and how healthy we are in old age? The short answer is 'yes' and in a number of unexpected ways.

Take first the simple relationship between height, weight and mortality. Our height is largely determined by our nutritional status in the womb and during the first two years of life; later illness or trauma, including severe malnutrition, can affect our growth, but only a very severe and prolonged insult can have permanent effects on our ultimate height. It is therefore at first sight very surprising that height is related to adult mortality. How can what happened to us before the age of two affect how long we live? But the evidence is that it does, both in historical populations which were much more deprived than we have been and in modern populations which have not suffered any serious deprivation. This graph clearly shows that, in two very different populations, taller people are likely to live longer, although very tall people may not do quite so well.

Nutritional status later in life can, however, modify the relationship, as is shown by the curve relating mortality to body mass. Here we can see that one's expectation of life is affected both by being too thin and by being too fat.

But nutritional status, measured by body size, affects much more than how long we live. There is increasing evidence that it is an important component of what an economist calls 'human capital', the set of attributes and competences which we develop in childhood, youth and early adulthood and, in a sense, live on for the rest of our lives. The simplest example of this is bodily strength, which is particularly important in societies which rely heavily on human physical labour, such as most societies in the past and many still today. There is abundant evidence that, in modern underdeveloped societies, taller people command higher wages; this is probably because their height is seen as indicative of greater strength or fitness. Schultz, a development economist, found that: 'An additional centimeter in adult height is significantly associated with a 1.5% higher wage for men and a 1.7% higher wage for women in Ghana; 1.4% and 1.7% higher wages in Brazil, respectively.'

But, intriguingly, this relationship is found not only in underdeveloped societies, but in developed societies such as ours, where physical strength is less required; Schultz found that an additional centimetre brought an increase in wages of 0.45 and 0.31 % for men and women respectively in the United States (Schultz 2002). Another study of large datasets from the US and the UK found that 'For both men and women, the relationship is striking: a one-inch increase in height is associated with a 2 to 2.5 percent increase in income or earnings. An increase in US men's heights from the 25th to the 75th percentile of the height distribution - an increase of four inches - is associated with an increase in earnings of 10% on average' (Case and Paxson: NBER WP 12466, 2006)

Why should this be?

One answer is that our society still puts a premium on health and sees height as an indicator of likely good health and thus enhanced productivity. But it is also probable that the wage premium for height reflects the effects of early nutritional status on cognitive development. It has long been known that deprivation in infancy reduces cognitive achievement and, in childhood, hampers learning. It now seems likely that the effects of early nutritional status have long-lasting effects on our productivity and earning power; they affect our human capital.

Even in as rich a society as ours, the lower the birthweight of a child, the lower his or her cognitive development. As one recent British study concluded: "Birth weight was significantly and positively associated with cognitive ability at age 8 ... between the lowest and highest birthweight categories after sex, father's social class, mother's education and birth order was controlled for. This association was evident across the normal birthweight range (>2.5 kg) and so was not accounted for exclusively by low birth weight. The association was also observed at ages 11, 15, and 26, and weakly at age 43" (Richards

et al 2001)

We know that a major determinant of low birthweight is the nutritional status of the mother, which is itself affected (though not entirely determined) by her nutritional status in early life. This evidence therefore suggests that deprivation, including poor cognitive development, can be transmitted across the generations as well as being reinforced by poverty in each generation. This is not a matter of genetic inheritance, but of the cumulative and continuous effect of the environment.

More extreme deprivation, for example the poverty characteristic of many underdeveloped countries, has even greater effects. A recent survey concluded, for example, that in such countries: 'Poorly nourished children tend to start school later, progress through school less rapidly, have lower schooling attainment and perform less well on cognitive achievement tests when older, including into adulthood.'

It therefore appears that our early life - and even the life of our mother - affects our health and welfare throughout our lives, with deprivation leading to relatively low strength, relatively limited cognitive development, relatively low productivity and relatively early death. Even in rich societies, the effect persists; as two American economists, Case and Paxson, have put it in a pithy summary of the evidence: "On average, tall people earn more because they are smarter". They are also likely to marry well, to live longer and, of course, to pass on these advantages to their children and even their grandchildren.

If this is true today, how much truer was it in the past. Our society and economy three centuries ago, like modern underdeveloped societies, was characterised by such poverty, such poor levels of nutritional status, that large sections of their populations had bodies - stunted and wasted - which were simply incapable of sustained physical work and minds whose cognitive capacities were similarly stunted. This effect was not confined, however, to small sections of society but, in different ways, influenced the physical and intellectual capacity of whole societies. It is notable, for example, that upper-class boys in the early nineteenth century, who were in no way deprived, still only attained heights well below the average of modern populations, several centimetres below the heights of upper-class children today. At the extreme, boys from London slums were, on average, shorter than all but the most exceptionally short boy today. This suggests that, right across the income range and because of childhood experiences, the human capital of men and women in many parts of the world was - and probably still is - limited; it is still below full human potential.

Poor nutritional status and its long-term effects are therefore a consequence of lower levels of economic development. But it is also a cause of such underdevelopment. Societies become locked into poverty, with their peoples so malnourished that they cannot produce the goods and services to feed, clothe and house themselves and their families. However, if nutritional status can be raised, even if only by a little, there is the possibility of a dynamic and self-reinforcing process by which, generation by generation, the population becomes more productive and long-term economic development becomes possible.

How does such a perspective affect, for example, our view of the origins of modern economic growth? Economic historians like myself still argue about why the Industrial Revolution occurred and about whether it was due to dramatic inventions or to smaller, less perceptible, changes. The evidence which we have now amassed about the nutritional status of men and women in the past gives a different perspective. It seems likely that the entire output of the economy in the eighteenth century, an age in which physical work by humans was still dominant, was limited by the nutritional status of the population. They were, on average, simply too weak to produce more output and many, at the lower end of the income distribution, were barely able to work at all. It is not surprising that there were so many beggars, and that working hours and days were limited.

However, since the principal cause of this was the limited food supply which the population could produce, even slight improvements in the productivity of agricultural labour - perhaps a run of good harvests or an apparently minor change in agricultural practices - could trigger a virtuous circle. More food meant healthier and stronger workers who could then produce more food. And this virtuous circle could operate across the generations, as mothers produced slightly healthier children who could then produce slightly more, live slightly longer, and produce slightly healther children of their own. The evidence that this happened is in the statistics of their height and of their expectation of life. Moreover, it was not only their bodily strength that improved but also their cognitive abilities, triggering other changes in the economy through better education and improved technologies and other working methods.

People became at the same time stronger, longer lived and more intelligent; if one multiplies these together, into units of work effort, and remembers that throughout the eighteenth century there was also a

significant rise in the British population, then one can see that the population had a much greater capacity for work in 1800 or in 1850 than it had had one or two centuries earlier.

This story - or hypothesis - may be less appealing to some than the account of the Industrial Revolution as a period of 'great inventions' or a 'wave of gadgets'. But it has always been difficult to demonstrate that the inventions which appear in the schoolbooks, particularly in the textile industry, were pervasive enough to produce the widespread economic growth which seems to have occurred. It is much more plausible, I think, to attribute it to a general improvement in our nutrition and health. This is, if you like, a democratic explanation of the industrial revolution, as a pervasive and prolonged improvement in our people, not a elitist explanations which stresses the influence of a few clever or ingenious men.

Such a process is slow, a matter of apparently slight shifts in averages, such as average height and its causes. But economic growth was also slow for many decades. What is crucial to my explanation is that it is self-reinforcing. The greater health and strength of one generation would provide the increased output which would then enhance the nutritional status, and thence the productivity, of the next generation. The increased cognitive capacity, dare I say increased intelligence, of succeeding generations would also fuel invention and innovation in ways which would themselves reduce the need for physical strength. In recent years, it would help to explain the increases in measured intelligence which have been experienced in all developed countries, although some doubt that nutritional status can have increased enough to explain the dramatic increases which have been seen; improved teaching and learning methods probably deserve some of the credit.

Are these ideas 'heightist' or even racist? No. The evidence emphatically does not suggest that the short nations of the world, the poor nations, have populations who are inherently less intelligent than populations in the tall, rich nations. Of course a short nation contains proportionately as many intelligent people as a tall nation. It is the society as a whole that has simply not yet fulfilled its collective potential. Height, or intelligence, is not the preserve of any part of the world's population. Just as we see that poor nations grow taller as they grow richer, so we can expect that the limitations on cognitive development which are caused by poverty and disease will disappear as those countries become richer and healthier. So the process will continue, since there is no reason to think that a limit has been reached, unless we destroy our societies by foolish actions.

Economic historians are not trained to be forecasters, but I will venture some predictions. First, we have not yet fully seen the impact of the years of sustained economic growth since the second world war. That impact can be seen in longer life expectancy and longer years of healthy life, which have benefited my generation - born during the war - and are benefiting our children and grandchildren. On the basis of all that we know about the long-term effects of good nutritional status in childhood, we can expect them to live longer and live healthier, even more than ourselves. We may also see a continued improvement in cognitive achievement, particularly when it is combined with such aids to learning as information technology now provides. In this context - and also bearing in mind the possible effects of the ban on lead in petrol - I do not find surprising the continued rise in measured educational achievement, which is sometimes attributed to 'dumbing down'.

Even within the developed world, there is still scope for improvement by catching up the most successful. Although we are one of the tallest of European nations, we still lag noticeably in height behind the Dutch. And, despite its riches, the United States, which is hampered by inequality and poor health care for parts of its population, lags also, as do even more so many of the countries of central and eastern Europe. To rectify this, there is everything to be said for devoting even more resources than we currently do to maternal and child health.

But the real prize could come in the rest of the world, where the demographic and anthropometric data demonstrate clearly the continued poverty and low nutritional status of hundreds of millions of people. Many of these countries are still caught in the trap experienced by Britain at the start of the industrial revolution, in which poverty and poor nutritional status limited productivity and thus inhibited economic growth. The prize will come, I predict, from loosening those bonds, little by little, and reaping the benefit - generation after generation - in the form of slightly longer working lives, slightly greater productivity, slightly greater measured intelligence. At the moment, the stunting and wasting of bodies which can still be seen - and the deptrivation in brainpower, which cannot - is not only morally repugnant but a sure sign of unfulfilled human capacity, which the world can ill afford.

These are all optimistic predictions; are there any grounds for pessimism? It is often suggested that obesity and its correlates, such as increases in the incidence of diabetes, will negate the benefits of improved nutritional status; we will, in a sense, become so over-nourished that we put into reverse the improvements of two centuries. Obesity itself is certainly not a new problem, although its spread throughout the population and to the young may be. A difficulty in discussing this hypothesis is that the change is so recent and obesity is still relatively rare. I recall that, when I and my colleagues first began our investigations in anthropometric history, we relied heavily on the help and advice of the then doyen of growth studies, Professor Jim Tanner. When Jim Tanner published, in 1981, his History of the Study of Human Growth, obesity did not appear in the index. Nor was it covered in the editions in the 1970s of his much-thumbed textbook,Foetus into Man. I do not recall any public concern about obesity in Britain in the 1970s, while in the United States in the early 1980s it was regarded as a problem of the working class. Chou En-lai is said to have been asked to assess the effects of the French Revolution; he replied: 'it is probably too soon to tell'. The same is true of obesity.

It is indeed possible that obesity is a short-term reaction to a rapid improvement in nutritional status. The Nobel prize-winner, Amartya Sen, has suggested that the fast rising incidence of diabetes in India may be explained by the impact of much improved nutritional status on a population which was very poor in its youth. If that is so, it may be a transient phenomenon, which will be alleviated as succeeding generations are relatively well-nourished throughout their lives. It may be that the same will be true of obesity and that its incidence will therefore level off or diminish rather than growing to engulf us all.

It is even more difficult to speculate about the biggest question of all, that of climate change or, even more generally, whether the earth's resources will be sufficient to provide for the needs, or wants, of a population which is predicted to be half as big again by the end of this century as it is today. We simply do not know whether the improvements to human health, intelligence and productivity, perhaps combined with the declining birth-rates which have tended to accompany such improvements in the past, will be sufficient to outweigh the demands which the inevitably growing population will make. We do know that the predictions made by Thomas Malthus, three centuries ago, that growing population would outrun the food supply, have not come to pass; but that does not mean that they will not do so in the future.

We may therefore be living in a fool's paradise. But it is certainly true that, by comparison with the lives which our ancestors lived only ten or fifteen generations ago, we are living in a paradise. We are, on average, 14 times more productive and consume 14 times more than our ancestors did in the 1750s; our average ability to produce and consume has trebled even during my lifetime. And that paradise has been achieved, I believe, by the gradual improvements in nutritional status and its consequences which have been documented by anthropometric history.