# Net Nutrition over the Past Millennium:

# Methodology and Some Results for Northern Europe

by

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*Abstract*

This essay places the debate over human welfare during industrialization in the context of very long-term economic developments by examining an important aspect of living standards--health and nutrition--since the Middle Ages. I use average stature determined from military records along with heights inferred from skeletal data, a neglected source in economic history. Based on a modest sample of skeletons from northern Europe, average heights fell from an average of 173.4 centimeters in the early Middle Ages to a low of roughly 167 centimeters during the seventeenth and eighteenth centuries. Much remains to be learned about the chronological and spatial details of European height patterns prior to the eighteenth century, but taking the data at face value, this decline of approximately 6.4 centimeters substantially exceeds any prolonged downturns found during industrialization in several countries that have been studied. Significantly, recovery to levels achieved in the early Middle Ages was not attained until the early twentieth century. At this point the data are insufficient to test hypotheses, but it is plausible to link the decline in average height to climate deterioration; growing inequality; urbanization and the expansion of trade and commerce, which facilitated the spread of diseases; fluctuations in population size that impinged on nutritional status; the global spread of diseases associated with European expansion and colonization; and conflicts or wars over state building or religion. Because it is reasonable to believe that greater exposure to pathogens accompanied urbanization and industrialization, and there is evidence of climate moderation, increasing efficiency in agriculture and greater inter-regional and international trade in foodstuffs, it is reasonable to link the reversal of the long-term height decline with dietary improvements.

## Introduction

For over half a century, quantitative economic historians have pondered the fates of workers and other segments in the population during the industrial revolutions of the nineteenth and early twentieth centuries. While everyone agrees that the standard of living eventually improved, much discussion has focused on how various groups fared during the decades that industrialization actually unfolded. Scholars of the subject have asked who gained and who lost in the process (and why), and whether industrialization was accompanied by events that adversely affected health and human welfare. Debate has been particularly lively in the case of England, and factions have coalesced into camps of optimists and pessimists. Controversy persists because evidence about the past is often meager and, in any event, health and human welfare are complex and difficult to assess under the best circumstances of data availability (for a discussion of issues, see Engerman 1997).

This paper places the debate over human welfare during industrialization in the context of very long-term economic developments by examining an important aspect of living standards - health and nutrition - since the Middle Ages. I use average stature determined from military records along with average heights estimated from a neglected source, skeletal data.[1] Average height measures a population's history of *net* nutrition—diet minus claims on the diet made by work and by disease. [2] Considering the industrial period as a backdrop for comparative study, I describe the U-shape that average heights

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[1] Average heights calculated from skeletal data have long been used by physical anthropologists but little used by other social scientists. For a study of England oriented toward medical historians, see Stephen Kunitz (1987).
[2] Readers unfamiliar with the methodology of anthropometric history may want to consult the discussion and references in Steckel (1995).

took over the past millennium in northern Europe and suggest a research agenda for analyzing this remarkable time trend in health and nutrition.

**Background**

Although lacking survey results on the subject, I suspect that few scholars would challenge whether the substantial resources allocated to the standard of living debate have been worthwhile investments as a whole. No doubt, many would object to some books or papers, but all would recognize that industrialization has been the biggest news of the past two centuries on the economic front. Unquestionably, industrialization transformed social and economic life, and even poor groups within modern industrial countries have greater access to most types of material goods and live longer lives than the upper classes in the pre-industrial era. Study of industrialization is also warranted for insights that may help guide developing countries now undergoing the process.

Considerable devotion to the subject of welfare during industrialization is justified, but the neglect of the pre-industrial era is curious. The lack of attention cannot be explained by a supposition that industrialization was the only major dynamic feature of social and economic life over the past several millennia. Earlier transformations were arguably on par if not more significant, including the shift from foraging to farming, the rise of cities, and European expansion and colonization that began in the 1400s.

The neglect might be explained by temporal distance from the present, a forceful point among those scholars who believe that modern policy implications should flow from the work of most if not all economists, including economic historians. People of this persuasion may ask what could possibly be learned about problems in the modern world by studying the pre-industrial era. In reply, one might observe that the pre-industrial world of the past is relevant because parts of today's developing regions approximate pre-industrial conditions of the eighteenth or nineteenth centuries. More importantly, study of pre-industrial economies is justifiable as a form of basic research. All social scientists understand the value of large, diverse samples for generalizing about human behavior, and the past is certainly diverse. In any event, economic historians, and historians, are seldom beholden to arguments that research must demonstrate immediate applications. Many are content in viewing research purely as consumption, or satisfying desires of intellectual curiosity.

On a practical level, data availability is a problem, at least for the type of monetary measures that economists are accustomed to using, such as real GDP, real wages, or wealth. While it is certainly not true that abundant data exist for the taking, it is also not true that evidence is completely lacking. Over the years I have been impressed by the ingenuity of historians and economists in developing new data resources, a record that leads one to doubt whether most useful sources have been exploited. Recently, the frontiers of research were extended backward in time and over space, at least in the dimension of wages and prices (Allen 1998).

Finally, new data sources and methods have been developed for assessing human welfare. Speaking metaphorically, one may think of the history of human welfare in a country or region as a long sausage or salami; each slice represents a year (or other time unit) of social performance that can be divided into broad categories of health, material goods, and psychological elements, which may have spiritual or metaphysical components. The example of the new anthropometric history shows that a significant portion of the health component is measurable from military records and other sources of height data (Steckel 1998). Skeletal evidence greatly extends backward in time the portion of the salami that is visible, broadens it to include women and children, and unlike stature alone, includes information on degenerative health processes associated with hard work and ageing. This paper makes a small down payment on the larger research agenda of integrating the analysis of pre-industrial height data from skeletal records and military sources into the literature of economic history.

**Pre-industrial Heights**

Among the 8 countries studied in Steckel and Floud (eds.), *Health and Welfare during Industrialization*, all but Germany have some military height data that cover small portions of the pre-industrial era. In the absence of detailed information, economic historians may tend to view the pre-industrial world as a vague but homogeneous lump defined by its heavy reliance on agriculture, the preponderance of home manufacturing, and antiquated methods of production. On the eve of industrialization, average heights ranged widely from 155 centimeters in Japan to approximately 173 in the United States and Australia. Most European countries clustered near 164 or 165 centimeters, but the Swedes reached 168.

In all but the United States, the pre-industrial populations were also smaller, often by several centimeters depending upon the exact years of the comparisons. Considering the pre-industrial and middle phase, for example, the height differences were about 2 centimeters in France, roughly 4 centimeters in Japan, the Netherlands and Sweden, and about 5 centimeters in Britain (but note that average heights declined significantly in Britain for cohorts born in the 1840s and early 1850s). Average heights in the US were about 3 centimeters lower in the middle compared with pre-industrial times.

What were the important socioeconomic conditions affecting pre-industrial heights? It would seem appropriate to begin with mechanisms that were powerful in explaining height differences during industrialization—urbanization and abundant access to land. The two countries with the tallest people (Australia and the US) score well on the latter category and Sweden was the tallest and least congested of the European countries. Access to land tended to ameliorate poverty, helped promote dietary diversity and reduced the spread of disease by lowering population density. Countries with the shortest populations were relatively urban, a feature long known to have impaired health. Australians were tall despite a large (30%) urban population, likely because the cities were isolated from each other and from much of the rest of the world.

If low urbanization and low population density were good for health, it is a fair question to ask why so many of the pre-industrial populations were so short, compared with their industrial counterparts. After all, the adverse factors of urbanization and population density tended to increase with industrialization. With the exception of the US and Britain in the late industrial phase, there must have been something good for health about industrialization that more than offset the features that were bad.

## Extending the Record

Before attempting to generalize, or even begin to formulate a research agenda on the possible causes of small stature in the pre-industrial era, it is essential to inspect additional evidence. The time span available for study of pre-industrial heights from military records is rather short (or non-existent) in all countries.[3] Skeletal data, in which

[3] Some 17th century military records in France contain measurements of soldiers, which are useful for studying pre-industrial trends in heights. Komlos, Hau and Bourguinat (2001) report an upward trend (with

stature is inferred from long bone (femur) lengths, provide information on the more distant past. Before examining the results, however, it is worth discussing the methodology of using skeletons to estimate heights.

Valid use of skeletons requires knowledge of sex and age at death.[4] For all parts of the skeleton, the female elements typically have smaller size and lighter construction. These differences become pronounced in the skull and the pelvis beginning in late adolescence, but before these ages, sex cannot be reliably determined. The skeletal features of robust adult females may resemble those of small and light adult males, but using multivariate analysis, it is possible to estimate sex of adults with a high degree of accuracy in well-preserved remains.

Over a person's lifetime, the skeleton undergoes sequential chronological change. The changes are pronounced in dentition among children and in fusion of the epiphyses (or "growth plates") in various bones of children and in young adults. Among older adults, there are systematic changes in the shape of the pubic symphysis that are used as a guide to age. Above age 50, however, these techniques (and others) become increasingly unreliable, and for this reason, older adults are often grouped together for analytical purposes. In estimating the height of adults, it is the fusion of epiphyses in the long bones that is the key for estimating adult height. Once fusion has occurred, growth ceases and length does not change even with increasing age. On average, approximately 26 per cent of an adult person's height is contained in the femur bone. Trotter and Gleser (1952) developed the most widely used formula for converting femur length into height.

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moderate fluctuations) in average height for birth cohorts of the late 17th century to the mid-18th century. Further search efforts might reveal additional pre-industrial height records for other countries.

[4] For discussions of these issues see White (1991: 308-20) and Buikstra and Ubelaker (1994: chaps. 3-4).

Excavated burials may not reflect the once-living population if burials were geographically dispersed, excavation was incomplete or quality of preservation of the bones was poor. Therefore, in this line of work it is useful to compare results from a particular site with those from sites where these problems are thought to be minimal.

Table 1 gives details from individual studies found in a search of the literature in physical anthropology from sources easily accessible in the United States. Although some results were available for other parts of Europe, only northern Europe had studies that span the entire period from the early Middle Ages to the present. My first effort leaves a gap for the 15$^{th}$ and 16$^{th}$ centuries, which additional search will fill.

Table 2 summarizes results by era for those studies that give evidence for time periods as small as two or three centuries. Studies reporting results for burials during "Medieval Era" or the "Middle Ages" are lumped together in the middle of the table. It is remarkable if not stunning that the average heights during the early and late Middle Ages exceeded those observed for the eve of industrialization by several centimeters. While one should always devote some attention to the issues of representativeness and sampling in skeletal data, the large number of studies covering several northern countries suggests that the results cannot be dismissed as a statistical fluke or aberration. It is conceivable that all of the estimated heights for the Middle Ages were biased upward by some as yet undiscovered process of selection, but one would then wonder why that selection process ceased to be a factor in the centuries immediately prior to industrialization.

Generalizing about pre-industrial height trends will be difficult without more evidence for the 15$^{th}$ through the 18$^{th}$ centuries. It seems reasonable to suggest, at least tentatively, that net nutritional conditions of the past millennium reached a low point in

Europe prior to the onset of industrialization. Between the Middle Ages and the twentieth century, heights were U-shaped with a minimum attained sometime between 1450 and 1750, when historical heights become widely available from military records. The onset of the decline (and ultimately its causes) can be established only by a search for more evidence from published or unpublished sources.[5]

Taking the evidence at face value indicates that average heights fell from an average of 173.4 centimeters in the early Middle Ages to a low of 165.8 centimeters during the seventeenth and eighteenth centuries. This decline of 7.6 centimeters exceeds by a factor of two any fluctuations observed during industrialization. Recovery to levels achieved a millennium ago was not attained until the early twentieth century. Both the extraordinary level relative to recent times and the U-shaped time trend, are remarkable phenomena worthy of considerable study.

Some people may claim that genetic factors are responsible for the tall statures observed during the Middle Ages, pointing to the fact that northern Europeans are taller, even today, than those from more southern European countries (Schmidt, Jorgensen and Michaelsen 1995). But the southern Europeans of the modern period, who tend to be poorer, are catching up, and in any event, studies of children around the globe indicate that children who grow up under similarly good environmental conditions have about the same heights (Malcolm 1974; Martorell and Habicht 1986). If genetic factors were relevant, presumably they had little or no effect on the trend within areas surrounded by

[5] The National Science Foundation recently funded an extensive project that will collect and analyze data from skeletons covering the last 10 millennia in Europe. The effort will obtain not just heights (from femur lengths) but also information on degenerative joint disease, dental decay, anemia, and other skeletal indicators of chronic biological stress. A module in a larger project envisioned on a global history of health, I will work with 3 co-investigators and numerous collaborators in Europe in gathering and analysing skeletal data that will be matched with socio-economic and climate information. For additional information see the project's web site at global.sbs.ohio-state.edu.

the North Sea and the Baltic. Thus, I seek environmental explanations for northern Europe's U-shaped trend in stature.

In suggesting candidates for further study, it is relevant to recall that average height measures a population's history of *net* nutrition - diet minus claims on the diet, made by work and by disease. Urbanization and growing population density, which occurred during industrialization, increased exposure to disease. Could the diet have been poorer and work more arduous in pre-industrial times, by enough to offset the benefits of lower population density? And if the diet was poorer and work was more arduous, why was net nutrition so good before the sixteenth century?

The data at hand confront conventional wisdom about changes in living standards since the Middle Ages, and lead one to ask: Why did net nutrition decline sometime between the Middle Ages and the pre-industrial period, at a time when modest economic growth probably occurred?[6] Why did heights generally improve during the nineteenth century, albeit with interruptions in some countries, when some factors adverse to heights (urbanization, inequality and business cycles) were getting worse?

As I do not have convincing answers to these questions, I look forward to additional research. It seems to me, however, that the millennium long U-shape of average stature in northern Europe might have been connected with seven major phenomena: climate change; growing inequality in real incomes after 1500; urbanization and growth of trade that spread diseases; wars of state building; religious conflicts; the global spread of new varieties of disease associated with European expansion and colonization; and population cycles. We are faced, then, not with a dearth of plausible explanations but rather

[6] See Maddison (2001) for a discussion of economic growth since the Middle Ages.

measuring their impacts on health and weeding out influences among those that were unimportant.

Possible Causes of Good Net Nutrition during the Middle Ages

At the outset, it is useful to consider why average heights were surprisingly large during the Middle Ages. One might debate the representativeness of the results, something that is useful more generally of findings so at odds with preconceptions. Because numerous skeletal studies are essentially uniform in reporting statures in the Middle Ages that were tall by standards of the late nineteenth century, however, it seems prudent to accept them at face value (at least provisionally) and move to possible explanations.[7]

According to the data at hand, northern European heights did not consistently exceed those of 800-1300AD until the early twentieth century. One important factor in this remarkable may have been climate. Agriculture during the period from about 900 to 1300AD benefited from what climate historians call the "Medieval Warm Period" (see Figure 1).

Based on ice cores, tree rings and other sources, climate historians believe that temperatures during this era were as much as 2-3 degrees (centigrade) warmer than a few centuries later, and 0.7 to 1.0 degrees above 20th century averages (see Fagan 2000). At the beginning of this era, the Vikings settled Iceland and later Greenland. This temperature change may not appear to be significant, but it was enough to extend the growing season by 3-4 weeks in many settled regions of northern Europe. The weather

[7] This is not the first time that anthropometric historians have found surprising if not startling results. The very small statures of slave children followed by remarkable catch-up growth, the American height decline

was sufficiently warm that commercial vineyards were viable 300 to 500 kilometres north of their range in the 20th century. Moreover, it allowed cultivation of previously unavailable land at higher elevations. Therefore, a population that was probably smaller relative to later eras, quite possibly had a portfolio of better land from which to choose in producing crops. A result would have been more agricultural output (at the same or less work effort) compared with the centuries immediately following the Middle Ages.

It is well known that economic isolation, in the form of little trade beyond local interaction, also characterized life during the Middle Ages, at least relative to later centuries when regional commodity markets developed significantly. Anthropometric historians have noted the benefits to health and average heights of geographic isolation, low population density, or lack of commercial development for outlying areas within Sweden, Austria-Hungary, Japan, Ireland, and the United States (Sandberg and Steckel 1987; Komlos 1989; Shay 1994; Margo and Steckel 1982, 1992; Nicholas and Steckel 1997; Cuff 1998). The protective effect of isolation, in the era before effective public health, probably operated through insulation from communicable diseases. In this regard, it is notable that the bubonic plague made its dramatic appearance in the significant revival of trade during the late Middle Ages.

Urban areas were bad for health, as established from their high mortality rates and the small statures of those who resided in such places for a significant portion of their childhood growing years. To my knowledge, this demographic phenomenon was found in all areas of the world until the late nineteenth or early twentieth centuries, when public health measures and improvements in personal hygiene significantly reduced exposure to

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during the mid-nineteenth century and the very tall statures of the Equestrian Plains tribes in the United States are three additional examples.

pathogens. Moderately large cities were absent from northern Europe until the late Middle Ages (for discussions of urban growth see De Vries 1984; Hohenberg and Lees 1985). As late as the end of the 13th century, significant urbanization was confined mainly to southern Europe, in northern Italian towns such as Milan, Florence, Venice and Genoa, each of which probably exceeded 100,000 in population. At this time, Paris was the only city in northern Europe that may have fallen into this category. The southern Low Countries were moderately urbanized by the late Middle Ages (the 14th century), but the largest city, Ghent, probably had no more than 50,000 inhabitants, while London and Cologne held fewer than 40,000 people at this time. Therefore, the overwhelmingly rural distribution of the population was an asset for health.

Possible Factors in the Health Decline

A cooling trend began around 1200 and by the 14th century, weather related events began to cause havoc in northern Europe (Fagan 2000). By the late 14th century, the Vikings had abandoned Greenland and in the next century, England no longer cultivated wine. By 1600, when the coldest two centuries of the Little Ice Age began, pack ice surrounded Iceland for much of the year, the Thames River often froze during the winter, glaciers advanced significantly in the Alps, and vast schools of cod had long since left European waters for warmer temperatures of the western Atlantic. The climate change was likely to have imposed greater economic and health costs on northern Europe where food production existed under weather conditions that were closer to the margin.

Important for agricultural production and health, the climate change was irregular. Imbedded within the general cooling period of 500-600 years were numerous seesaws of 15 to 40 years' duration, several of which are visible in Figure 1. The changing weather patterns made it difficult for individuals alive at the time to identify true long-term trends, which were noticeable only with intergenerational perspective. The lack of knowledge about actual trends postponed adaptations to the cooling climate, and during temporary reversals of cooling, encouraged investments in ways of farming and living that later proved unsuccessful.

Urbanization and growth of trade that began in the late Middle Ages gathered steam in the 16$^{th}$ and 17$^{th}$ centuries. In northern Europe, there was only one city of 100,000 or more people in 1500 (de Vries 1976, 73). By 1600, the number of people living in such places had quadrupled, and within another century it had tripled again. As height studies for the late eighteenth and early nineteenth centuries show, large cities were particularly hazardous for health, acting as reservoirs for the spread of communicable diseases (Steckel and Floud 1997: chap. 11). Therefore, it would not be surprising if urbanization following the Middle Ages contributed to an overall decline in health.

The spread of disease that began with revival of trade and urbanization were reinforced by another source of pathogens that began in the late 1400s, and later intensified: global exploration and trade. The voyages of Columbus and Vasco da Gama were merely the first of thousands by which Europeans acquired global information that was used to build and maintain colonial empires. Within 300 years, Europeans had mapped most of the globe and established numerous colonies or trading centers on all continents or islands significant for producing saleable products. Syphilis is only one of numerous diseases that spread during this era. It is well known that the early stages of globalisation began in the late 1400s and eventually led to the world-wide diffusion of many diseases into previously isolated regions or continents (Crosby 1972; 1986).

As a measure of net nutrition, average height is adept at measuring a population's consumption of basic necessities such as food, clothing, shelter, and medical care. In countries with high levels of per capita GDP, most people have enough of these to satisfy basic needs. But in poor countries or among the poor in moderate-income countries, large numbers of people are biologically stressed or deprived, which leads to stunting. In addition to income, average height is therefore sensitive to the degree of inequality (Steckel 1983; 1995). It is difficult to acquire information about income or wealth inequality in the distant past, but Hoffman et al. (2000) have been ingenuous in assembling related information by using information on the prices of products heavily consumed by the rich or by the poor. In their study of price patterns for staple foods and fuels relative to the prices of luxury goods, such as servants, they find that real inequality rose considerably during the 16th century and remained high until the 20th century. It was during the era from 1500 to 1650, however, that the rich benefited most from soaring land rents (a source of income for many of the well-off) while the poor faced higher prices for food, housing and land. As far as Hoffman et al. can tell, this trend persisted throughout most of Europe. Since the poor comprised a large segment of the population, it is plausible to believe that growing inequality could have increased biological stress in ways that reduced average heights in the centuries immediately following the Middle Ages.

Although state building could be credited, in many cases, with eventually improving economic efficiency, the early stages of the process also absorbed resources, cost human lives in conflict, and may have increased inequality. Someone might be able to argue that religious wars and conflicts improved health when or shortly after they occurred, but I find it difficult to imagine a mechanism. From the War of the Roses in the late 15th century and the Reformation in the early 16th century, many parts of Europe were in sporadic and sometimes protracted conflict or turmoil until the conclusion of the Napoleonic wars in 1815.

Economists and historians have long discussed Malthusian processes affecting population health and growth. Positive checks on growth, in the form of higher mortality rates created by growing pressure of population on resources, likely would have led to diminished stature. John Komlos (2000) has argued that industrialization was an adaptive response to such pressures, but presumably they existed (without or with less adaptive success) in earlier centuries. The course of population over the past millennium is reasonably well chronicled (see McEvedy and Jones, 1978) and plausibly periods of rapid growth that pressed on available resources and given technologies could have been a factor in height trends. The rapid growth of population during the 11th through the early 14th centuries, for example, might have been a factor contributing to height declines of the late Middle Ages.

It would be premature to attempt to identify an era that was the worst in the last millennium for European health and nutrition, but historical evidence suggests that the 17th century is a leading candidate (de Vries, 1976). Contributors to *The General Crisis of the Seventeenth Century* (Geoffrey Parker and Lesley Smith, eds., 1997), focus on Europe but argue that the hardship probably spread well-beyond this region. During this century numerous adverse forces acted together. It was part of the coldest period of the Little Ice Age, and subsistence crises were numerous. Religious turmoil was raging as signified by the Thirty Years War, and political instability was marked by the English Civil War and by numerous peasant uprisings. Economic inequality was intense as indicated by the rise in the price of necessities relative to luxuries. Global colonisation and the associated spread of diseases were in full swing, as was a rapid increase in the number of large cities. It remains, however, to connect these events to changes in average stature.

Height Recovery

The forces that led to increasing average heights are difficult to pinpoint without additional evidence on the times and places where increases occurred. It is hard to see how industrialization could have reduced exposure to pathogens. Growing population congestion, migration and trade associated with the process were likely to have spread communicable diseases. If correct, one must look to other factors, such as the retreat of the Little Ice Age that could have contributed to higher yields in agriculture. There were also other sources of improving productivity in agriculture that began in the $18^{th}$ century, such as new crops for forage and food, new crop rotations, enclosures, better drainage systems, and mechanical equipment. McKeown (1983) has been the strongest advocate for better diets in improving health in the nineteenth century, and Fogel (1985) has used data on average heights and agricultural production to buttress and quantify this point of view. Razzell (1993) and Livi-Bacci (1983) have downplayed the contribution of nutritional inputs to improving health over the long term, citing factors such as the independence of many diseases from nutrition, human adaptability to food availability, smallpox inoculation, and changing virulence of diseases.

While more research should be done, connections have been made between rising heights and improving diets in specific countries. Weir (1997) argues that growing meat consumption contributed significantly to rising heights in nineteenth-century France.

Sandberg and Steckel (1980) suggest that diffusion of potatoes was important to improvements in stature in Sweden in the early nineteenth century. More generally, dietary improvement in nineteenth-century Europe was made possible by technical improvements, such as light iron ploughs, steam threshers, mechanical harvesters, and commercial fertilizers, as well as by agrarian reforms such as enclosures or emancipation of serfs (Jones 1968; Trow-Smith 1967; Tracy 1964). In the middle of the nineteenth century, diets also received a boost from the free trade movement. This and greater speed and lower transportation costs on long ocean voyages made it feasible to import foodstuffs from Australia and from the land-rich countries in the Western Hemisphere, principally the US, Canada, and Argentina (O'Rourke and Williamson 1999). There is also evidence that public health measures, though based on an inaccurate theory of disease causation, were somewhat effective in reducing mortality rates in cities (Szreter 1988).

An increase in average height may have been assisted by gains in consumption per person that followed from reductions in conflicts that absorbed resources. Although there were some revolutions and assorted small wars in Europe during the nineteenth century, the Napoleonic Wars, which ended in 1815, was the last major conflict until World War I. Some religious strife persisted, but in fewer places and at lower levels than existed during the Reformation.

## Concluding Remarks

While there are certainly qualifications to be noted, the major empirical finding reported in this paper is the U-shaped pattern in average heights from the early Middle Ages through the late nineteenth century in northern Europe. After a long period of approximate stability at levels that were impressive even by standards of the late nineteenth century, heights declined sometime after the end of the Middle Ages. Plausibly, the height decline might be linked with climate change that accompanied the onset of the little ice age; growing inequality; urbanization; the global spread of diseases after the late 1400s; and conflicts associated with state building and religion. Because it is reasonable to believe that greater exposure to pathogens accompanied industrialization, and there is evidence of growing efficiency in agriculture and greater trade in foodstuffs, it is reasonable to link height gains during the early and mid nineteenth century with dietary improvements.

Much research remains to be done on the exact time-path of average heights, and substantially more information from skeletal evidence is available. A large research program is now in the planning stages to gather this evidence and analyze it in light of related information on climate and of socioeconomic information from historical sources and from the archaeological record.

For over half a century economic historians have focused on the question of whether there was immiserization during industrialization, a debate that has split researchers into camps of optimists and pessimists. This continues to be an interesting topic for research, but with the perspective of 1000 years of history, whatever happened with regard to downturns in welfare during this era, they were likely small compared to the vast changes that probably occurred since the early Middle Ages. Therefore, economic historians who are inspired by variation and diversity in the historical record would do well to consider this much broader time span of evidence.

Table 1: Average Heights in Northern Europe Estimated from Adult Male Skeletons

| Era | Place | Avg. Height (cm) | Sample Size | Source |
|---|---|---|---|---|
| 9-11th C | Iceland | 172.3 | 22 | Steffensen (1958) |
| 9-17th C | Iceland | 172.2 | 71 | Steffensen (1958) |
| 10-11th C | Sweden | 176.0 | 8 | Gilberg (1976) |
| 11-12th C | Iceland | 172.0 | 27 | Steffensen (1958) |
| 11-17th C | Iceland | 171.0 | 16 | Steffensen (1958) |
| 12th C | Norway | 170.2 | 42 | Hanson (1992) |
| 12th C | Britain | 168.4 | 233 | Munter (1928) |
| 12-13th C | Norway | 172.2 | * | Huber (1968) |
| 12-16th C | Iceland | 175.2 | 6 | Steffensen (1958) |
| 13th C | Denmark | 172.2 | 31 | Boldsen (1984) |
| 13th C | Sweden | 174.3 | 66 | Gejvall (1960) |
| 13-14th C | England | 171.8 | * | Huber (1968) |
| Middle Ages | Sweden | 170.4 | 457 | Steffensen (1958) |
| Middle Ages | Denmark | 172.0 | 190 | Bennike (1985) |
| Middle Ages | Denmark | 172.6 | 43 | Bennike (1985) |
| Middle Ages | Norway | 172.1 | 314 | Holck &Kvall (2000) |
| Middle Ages | Denmark | 175.2 | 27 | Holck (1997) |
| Middle Ages | Norway | 167.2 | 1792 | Holck (1997) |
| Middle Ages | Sweden | 170.4 | 457 | Werdelin (1985) |
| 13-16th C | Holland | 172.5 | 87 | Maat et al. (1998) |
| 11-16th C | Holland | 176.2 | 23 | Janssen and Maat (1999) |
| 11-16th C | Sweden | 172.8[a] | 499 | Arcini (1999) |
| 17-18th C | Iceland | 169.7 | 17 | Steffensen (1958) |
| 17-18th C | Holland | 166.0 | 41 | Maat (1984) |

Table 1 (con't)

| | | | | |
|---|---|---|---|---|
| 17-18th C | Holland | 166.7[b] | 102 | Maat (1984) |
| 18th C | Iceland | 167.0 | 4 | Steffensen (1958) |
| 18th C | Norway | 165.3 | 1956 | Holck (1997) |
| 17-19th C | Iceland | 169.2 | 21 | Steffensen (1958) |
| 18-19th C | Britain | 170.3 | 211 | Molleson & Cox (1993) |

[*] Not available or missing information.

[a.] Simple average across 7 combinations of sites and dates.

[b.] Based on a sample of 102 men and women who were indistinguishable based on skeletal remains, of which about one half were men as determined from written records. The overall average was adjusted upward for typical sexual dimorphism (5 cm), to estimate male heights.

Table 2: Summary of Adult Male Height Trends in Northern Europe

| Era | Place | Simple Average of Average Heights (cm) | Source |
|---|---|---|---|
| 9-11th C | N. Europe | 173.4 | Table 2, rows 1, 3, 4 |
| 12-14th C | N. Europe | 171.5 | Table 2, rows 6-8, 10-12 |
| Middle Ages | N. Europe | 171.4 | Table 2, rows 13-19 |
| 17-18th C | N. Europe | 167.5 | Table 2, rows 23-25 |
| 18th C | N. Europe | 166.2 | Table 2, rows 26-27 |
| 17-19th C | N. Europe | 169.8 | Table 2, rows 28-29 |
| Late 19th C | Sweden, Netherlands, Britain | 169.7 | Sandberg and Steckel (1997: 129); Drukker and Tassenaar (1997: 341); Floud and Harris (1997: 102). |
| 1930 | Sweden, Netherlands | 172.5 | Sandberg and Steckel (1997: 129); Drukker and Tassenaar (1997: 341). |

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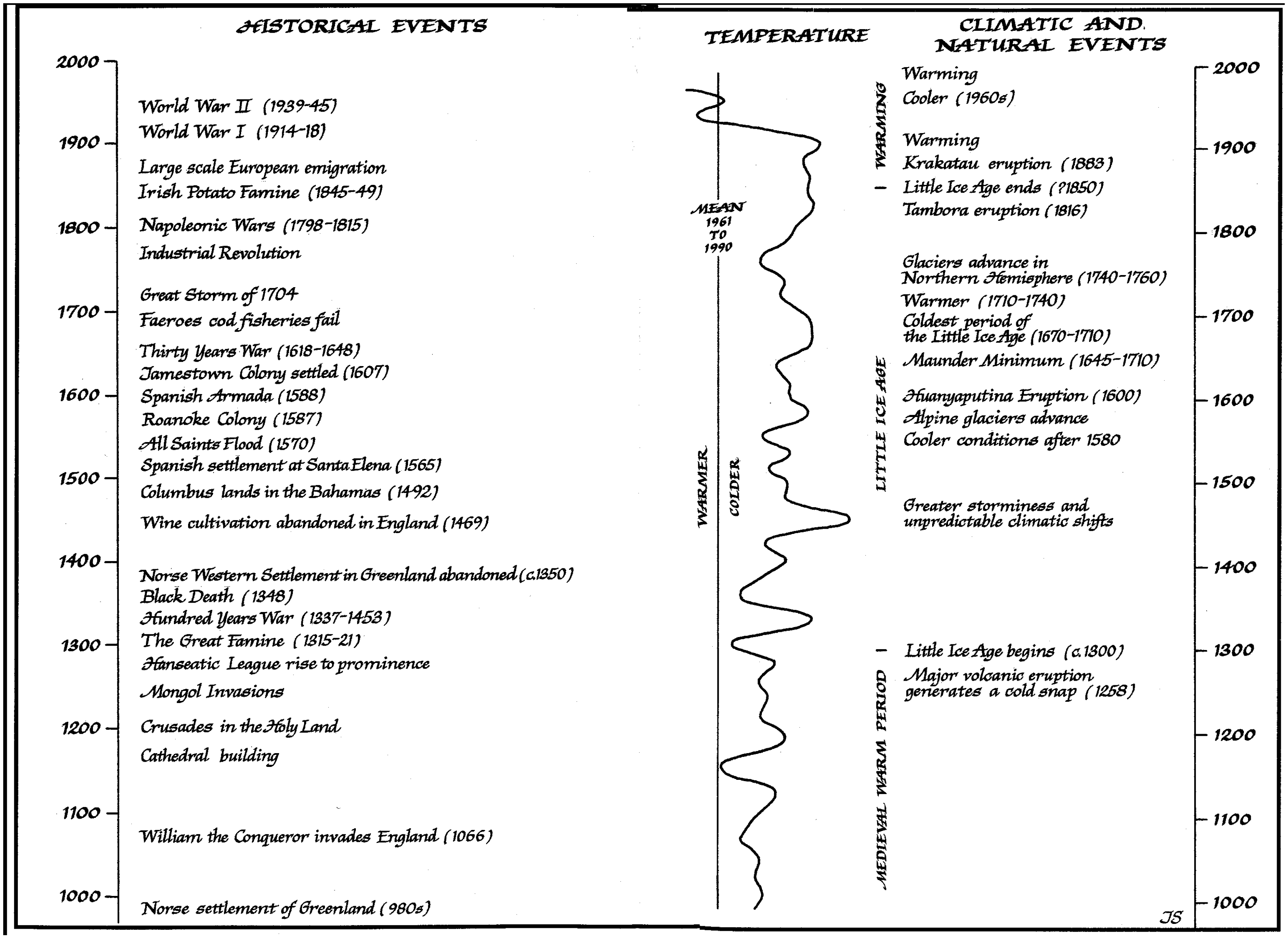
HISTORICAL EVENTS
TEMPERATURE
CLIMATIC AND NATURAL EVENTS
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1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
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Little Ice Age begins (c.1300)
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JS

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