# Global Warming and the Secular Increase in Human Height

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Abstract: The relationship between human physical stature and climate at the end of the 17th century is examined and the argument is advanced that a circa 5 cm increase in the height of French adult men was brought about by the end of the "Little Ice Age". On the basis of this finding the hypothesis is advanced that the secular upward trend in human height in the 20th century might well be associated not only with such man-made factors as improvements in the production and distribution of nutrients, progress in public sanitation and in medicine, but, possibly, also with global warming. More research on this issue would be useful.

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Global Warming and the "Secular Trend" in Human Height

Our limited knowledge of the physical stature of human populations prior to the 18th century has been based entirely on scattered archeological evidence. Written records recently found pertaining to the height of French soldiers enable our information to be extended back well into the 17th century. The French military administration was the first to begin to measure and record the height of recruits upon enlistment in 1716 (Chateau de Vincennes). The height of the French adult (age >23) male population was estimated on the basis of a sample (N=16,000) drawn from these documents for birth cohorts of c. 1670 to 1763 (Komlos, Hau and Bourguinat 2001). One of the major findings is that the French population was extremely short in the 17th century: about 161 cm[1] (Figure 1). This is the first written evidence showing how low living standards were during the so-called Little Ice Age. However, heights increased very rapidly toward the turn of the 18th century, coinciding with the secular warming trend. We suggest below that in the absence of much institutional or technological change, the direct (and indirect) effects of climate on the human organism must have been substantial. Moreover, although global warming in the 20th century was accompanied by considerable institutional and technological change, by analogy, the direct effect of climate should be considered as one of the possible causes of the secular increase in height in the 20th century.

We compare heights to Swiss temperatures and a shorter series of recordings available for Paris (1680-1713) (Pfister, C. and W. Bareiss, 1994; Legrand, J.-P. and M. Le Goff, 1992: Pfister 1998, Pfister in collaboration with Brändli 2001).[2] The end of the Little Ice Age meant an increase of average annual temperature of about 0.42 ° C between 1674-99 and 1700-24. Simultaneously with the improvement in climatic conditions, heights increased at the turn of the 18th century at a rate of some 3 cm per decade to exceed 165 cm by 1706 (Figure 1).[3] While the impact of climate on human morphology has been often documented (Roberts

1958, Katzmarzyk and Leonard 1998, Komlos 1989, 61, Baten 2001), this is the first time that such a significant and immediate impact has been observed.

Climate can affect physical stature directly through influencing the basal metabolic rate so that the nutrient intake can be used for the body's growth, rather than for maintaining body temperature[4] (Leonard, 2000). "Cold requires a higher rate of basal metabolic rate and robs the body of energy that could be used for growth" (Bogin, 1999, 283). "In hot environments, excess body heat produced by mammalian metabolism... must be dissipated to the environment to avoid hyperthermic stress.... Relatively low body weight,...and relatively large body surface area, produced by having legs and arms relatively long in proportion to the size of the trunk of the body, assist in heat loss.... Large body surface area increases the potential for convection, conduction, and evaporation. In cold environments, a relatively large body volume and small surface area (i.e. relatively short extremities in proportion to trunk size) is the body type best suited for heat retention" (Bogin, 1999, 286-287). Seasonal growth effects provide further evidence that the climatic environment affects the growth process. "...at temperate latitudes, healthy well-nourished children grow more quickly in height during the spring and summer than they do during the fall and winter" (Bogin, 1999, 289). This may be caused by the effects of sunlight on the human endocrine system through growth regulating hormone activity. Hence, bright sunshine – the absence of clouds – has a strong effect on growth rate (Bogin, 1999, 291- 294). The influence of climate is significant in infancy (Ulijaszek and Strickland, 1993) and during the first two years of life (Cole, 2000).

Moreover, the quality of milk - an important factor in human growth (Takahashi, 1984) - can vary with environmental conditions (Bogin, 1999, 277). Vitamin $D_3$ - important to bone growth,- is synthesized by the skin... when people are exposed to ultraviolet light penetrating the atmosphere without cloud cover blocking the sun's radiation. The concentration of vitamin $D_3$ in cow's milk is a function of the amount of ultraviolet radiation reaching the ground. Brody found that in cow's milk "...the July levels of vitamin $D_3$ were at

200 percent of the yearly average, while the December levels were about 35 percent..." (Brody, 1945, 211; Bogin, 1999, 293). In sum, "greater amounts and exposure to ultraviolet light may have increased the rate of synthesis, calcium absorption,...and growth in height..." The effect of sunlight may be the reason why "... birth during the spring and summer months leads to greater average height later in life (Bogin, 1999, 295-6).

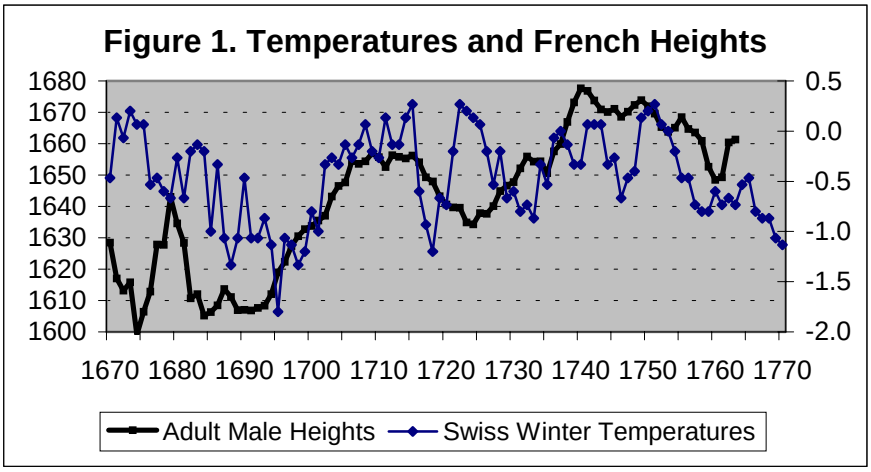
In addition, favourable summer temperatures could also bring about larger harvests and greater output of pasture grasses. These, in turn, would have affected the production both of meat and of dairy products of the largely self-sufficient peasantry. The negative correlation between height and grain prices, as well as that between climatic change and grain prices has been well documented [5] (Galloway, 1985, 1986, 1994; Woitek, 1998). One can infer that improved climatic conditions increased production, leading to lower prices, greater height (and also lower mortality).

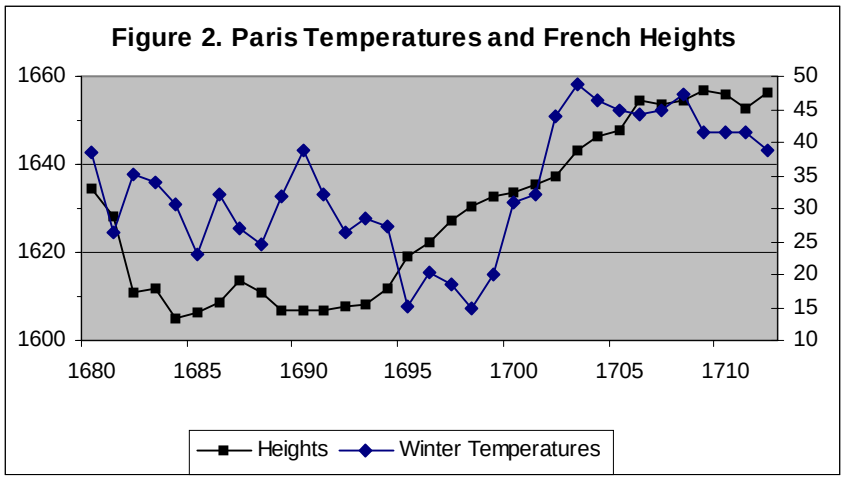
In, addition, it might be presumed that warmer weather also had a positive impact on the size of livestock, insofar as the amount of nutrients they themselves consumed could be used for their growth, rather than to maintain their body temperatures. Hence, the influence of climate both direct and indirect, on human physical stature is quite plausible. The longitudinal correlation is all the more noteworthy since the two series (height and temperature) pertain to quite distinct geographic units.[6]

To reiterate, we identified four kinds of factors why an increase in temperatures affects physical stature: a) food energy is converted into growth rather than used for temperature maintenance in human beings as well in domesticated animals; b) consequently domesticated animals produce more milk and meat, so that protein consumption of people increased; c) increased sunlight has a positive effect on the growth of both humans and animals, directly as well as through improvement in the vitamin D contained in milk; d).the amount of land under cultivation was increased in marginal areas of poor or marshy soil; lower rainfall and snow might make marshy areas more amenable to cultivation, leading to more grain output. The

amount of grain production increased also because of increased germination rates and increased growth of the plants and increased seed production so that yields per acre increased.

In spite of the considerable literature on the secular upward trend in human height in the twentieth century, the influence of global warming has not been discussed in this context (Ulijaszek 1998; Cole, 2000). Yet, temperatures have risen some 0.55 º C during the course of the 20th century, the warmest century of the millennium (United States 2000). Given the responsiveness of the human organism to changes in temperature of this order of magnitude at the turn of the 18th century, the hypothesis is worth entertaining that some part of the circa 15 cm increase in adult stature in the developed world since the late-19th century might well be attributed to climatic change. After all, the evolution in human height in the 20th century has been a global phenomenon, as has global warming. This issue seems worthy of further research.






References

Baten, Jörg, 2001, "Climate, Grain Production, and Nutritional Status in Eighteenth Century Southern Germany," *Journal of European Economic History*, 30, 1, Spring 2001, 9-47.

Bogin, Barry 1988. *Patterns of Human Growth*. Cambridge: Cambridge University Press, 1999, 2nd edition.

Brody, Samuel 1945. *Bioenergetics and Growth*, New York: Reinhold Publishing Co.

Chateau de Vincennes, French Military Archive, Paris.

Cole Timothy J., 2000, "Secular trends in growth," *Proceedings of the Nutritional Society*, May, 59 2:317-24.

Fagan, Brian, The Little Ice Age: How Climate Made History, 1300-1850. New York: Basic Books, 2000.

Galloway, Patrick R. " Annual Variations in Deaths by Age, Deaths by Cause, Prices and Weather in London, 1670 to 1830," *Population Studies* 39 (1985): 487-505.

Galloway, Patrick, R. "Long-Term Fluctuations in Climate and Population in the Preindustrial Era," *Population and Development Review* 12 (1986): 1-24.

Galloway, Patrick R. „Secular changes in the short-term preventive, positive, and temperature checks to population growth in Europe, 1460 to 1909," *Climatic Change*, 26, 1994: 3-63.

Katzmarzyk, P.T., Leonard WR. 1998. “Climatic influences on human body size and proportions: ecological adaptations and secular trends,” *American Journal of Physical Anthropology*. 106, 4, 483-503.

Komlos, J. 1989, *Nutrition and Economic Development in the Eighteenth-Century Habsburg Monarchy: An Anthropometric History* (Princeton; Princeton University Press).

Komlos, J. in collaboration with Hau, M. and Bourguinat, N., 2001. The Anthropometric History of Early-Modern France (Unpublished Manuscript, University of Munich, http://www.econhist.de/papers/france.pdf

Legrand, J.-P. and M. Le Goff, 1992. “Les observations météorologiques de Louis Morin,” Monographie, Nr.6, 2 Vols. (Trappes Direction de la Meteorologie Nationale Météo France, 1992).

Leonard, W.R., 2000, “Climatic influences on human energy metabolism,” *American Journal of Human Biology* 12, 2:298.

Manley, G., 1974, “Central England Temperatures: Monthly means 1659-1973,” Quarterly *Journal of the Royal Meteorological society*, 100:389.405.

Pfister, C., 1998, *Wetternachhersage. 500 Jahre Klimavariationen und Naturkatastrophen 1496-1995* (Bern: Paul Haupt).

Pfister C. in collaboration with Brändli, 2001, D. Raum-zeitliche Rekonstruktion von Witterungsanomalien und Naturkatastrophen 1496-1995; Schlussbericht zum Projekt 4031-33198 des NFP 31 (Zürich, Unpublished manuscript).

Pfister, C. and W. Bareiss (1994), „The climate in Paris between 1675 and 1715 according to the Meteorological Journal of Louis Morin,“ in Burkhard Frenzel, Christian Pfister, and Birgit Gläser (eds.), Climatic Trends and Anomalies in Europe 1675-1715 (Stuttgart: Gustav Fischer), pp. 151-171.

Roberts, D.F., 1953, "Body weight, race, and climate," *American Journal of Physical Anthropology*, 11: 533-558.

Ruff, C.B., 1994, "Morphological adaptation to climate in modern and fossil hominids," *Yearbook of Physical Anthropology* 37:65-107.

Takahashi E. 1984. Secular trend and milk consumption and growth in Japan. Human Biology 56. 427-37.

Ulijaszek, S.J., and Strickland, 1993, Nutritional Anthropology.

Ulijaszek, S.J., 1998, "The Secular Trend," In: *The Cambridge Encyclopedia of Human Growth and Development*, edited by S.J. Ulijaszek, F.E. Johnston, and M.A. Preece (Cambridge: The Cambridge University Press), pp. 395-98.

United States Environmental Protection Agency, 2000. EPA 430-F-00-011, April. Global Warming and our Changing Climate. Answers to Frequently Asked Questions. http://www.epa.gov/globalwarming/publications/outreach/gw_faq.pdf

Woitek, U. 1998. „Heights Cycles in the 18th and 19th Centuries," Discussion paper in Economics No. 9811, University of Glasgow.

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[1] Data presented in Figure 1 are moving averages for the five-years ending at the date of birth. Temperatures are five-year moving averages of mean annual temperatures centered on the year of birth of soldiers.

[2] Climate also improved in England at the end of the 17th century (Manley 1974). See also (Fagan 2000),

[3] This pace of change is at the very upper limit of the ones normally observed (1-3 cm per decade (Cole 2000)).

[4] The first law of thermodynamics (the conservation of energy) holds also for living organisms. Hence, the amount of calorie intake needed in order to maintain the body's temperature at between 36°C and 38°C is a function of the temperature of the environment. In humans a change in temperature from 25 to 20 degrees C. increases

heat production of the organism by 25% above that at basal rate. Even if well clothed, the inhalation of cold air imposes a heat loss on the human organism (Brody, 1945, pp. 12, 265, 288, 291; Ruff, 1994).

[5] For the effect of grain prices on mortality see Galloway (1985, 1986, 1994).

[6] It is true that a positive correlation does not exist in cross-sectional analysis: it is not the case that people are taller in warmer climates. Obviously other factors play a dominant role in determining that gradient.