Preventive Medicine **34,** 119–123 (2002)
doi:10.1006/pmed.2001.0966, available online at http://www.idealibrary.com on IDEAL®

Evolutionary Health Promotion: A Consideration of Common Counterarguments

S. Boyd Eaton, M.D.,*,[1] Loren Cordain, Ph.D.,† and Staffan Lindeberg M.D., Ph.D.‡

*Departments of Anthropology and Radiology, Emory University, 2887 Howell Mill Road NW, Atlanta, Georgia 30327; †Department of Exercise and Sports Science, Colorado State University, Fort Collins, Colorado 80323; and ‡Primary Health Care Center, P.O. Box 144, S-275 23 Sjobo, Sweden

Published online December 20, 2001

The proposal that Late Paleolithic (50,000–10,000 BP) ancestral experience might serve as a model for prevention research and even, if justified by experiment, as a paradigm for health promotion recommendations is sometimes discounted, before critical assessment, because of reservations based on unjustified preconceptions. Most often such biases involve comparative life expectancy, potential genetic change since agriculture, the heterogeneity of ancestral environments, and/or innate human adaptability. This paper examines these topics and attempts to show that none of them justifies a priori dismissal of the evolutionary approach to preventive medicine. Evolutionary health promotion may ultimately be invalidated because of its falsification by experiment or because another theory accords better with known facts, but these commonly held prejudices should not forestall its thoughtful consideration and investigative evaluation.

Key Words: **evolution; health promotion; prevention; life expectancy; genetic change; evolutionary medicine.**

INTRODUCTION

Evolutionary health promotion is based on three propositions:

• Since the appearance of behaviorally modern humans perhaps 50,000 years ago and particularly since the Neolithic Revolution of 10,000 years ago, cultural evolution has proceeded more rapidly than has genetic evolution, thereby producing ever-greater dissociation between the way we actually live and the lifestyle for which our genome was originally selected.

• This discordance fosters the chronic degenerative diseases that cause most morbidity and mortality in contemporary affluent nations.

• A logical model for prevention research (and, potentially, for health recommendations) is an amalgamation of the lifestyles prevailing among early, behaviorally modern humans, before agriculture accelerated genetic-cultural evolutionary divergence.

On initial consideration, these premises commonly evoke one or more of several seemingly valid reservations concerning comparative life expectancy, potential genetic change since agriculture, the heterogeneity of ancestral environments, and/or human adaptability. Such stumbling blocks sometimes interfere with objective assessment of evolutionary health promotion's strengths and weaknesses, so it seems reasonable to address these issues in some detail.

LIFE EXPECTANCY[2]

The most intuitive, most frequently expressed criticisms of the evolutionary hypothesis involve comparative life expectancy. In the first place, if Paleolithic diet, physical activity, reproductive experience, and so forth, were really healthier than they are in contemporary affluent nations, why do people now live so much longer? And second, chronic degenerative diseases are age-related, so longer-lived populations would be expected to manifest more such disease; Stone Agers just didn't live long enough for these conditions to become clinically evident.

[1] To whom correspondence and reprint requests should be addressed. Fax: (404) 352-2529. E-mail: sboydeaton@mindspring.com.

[2] Although technically imprecise, this article uses "life expectancy," "longevity," and similar expressions interchangeably to indicate the probable average number of years of life expected, at birth, for members of the entire population under consideration.

0091-7435/01 $35.00

Lifestyle and Longevity

Healthy lifestyle choices can improve an individual's weight, body composition, strength, and endurance. They can minimize risk of stroke, heart attack, diabetes, and cancer. What they cannot achieve is major impact on a population's average life expectancy. Completely eliminating the major known risk factors for nine leading chronic diseases[3] would increase life expectancy at birth by only 4 years [*1*]. While desirable, a 4-year gain pales when compared to the near 60-year increase that has occurred in Western nations over the past three centuries [*2*].

The reason that reducing chronic disease frequency has relatively little effect on average life expectancy is straightforward: these conditions are typically causes of late-life mortality. Whether a person dies at 80 as opposed to 75 has far less influence on average longevity measures than does infant and childhood mortality. Circumstances that increase likelihood of surviving potentially lethal infectious illnesses at age 2 are representative of factors capable of substantially impacting a population's average length of life. Whether the Paleolithic lifestyle is healthier than that common in contemporary affluent nations should be judged on its ability to affect parameters other than average life expectancy.

Age and Chronic Disease

A population with a life expectancy of 40 at birth will inevitably have much lower mortality from cancer, heart disease, diabetes, and stroke than will a population with an average life expectancy of 75. To this extent comparisons between recently studied hunter-gatherers[4] and citizens of affluent Western nations are invalid. Of course age-related diseases will cause more deaths in a society with a greater proportion of older individuals.

This coin has another side, however. While chronic degenerative diseases generally produce mortality in later life, they begin much earlier, often in childhood. This allows comparison between age-matched younger members of industrial and technologically primitive societies. Biomarkers of developing abnormality such as obesity, rising blood pressure, nonobstructive coronary atherosclerosis, and insulin resistance are common among the former, but rare in the latter [*3,4*]. Measurements of muscular strength and aerobic power reveal similar discrepancies [*5*], again favoring individuals whose lives more closely resemble the ancestral pattern. About 20% of hunter-gatherers reach age 60 or beyond [*6,7*], but even in this age bracket, individuals from foraging and other technologically primitive cultures appear almost completely free from manifestations of most chronic degenerative diseases [*8,9*] (osteoarthritis is an exception). Together, these observations strongly suggest that it is current Western lifestyle rather than age alone that promotes those "afflictions of affluence," the prevention of which is a major goal of contemporary health promotion efforts.

Why Do We Live Longer Now?

Life expectancy estimates for recently studied forager populations converge on a figure of about 40 years [*6,7,10,11*], and it seems reasonable to extrapolate a similar value for preagricultural, behaviorally modern Stone Agers. The adoption of farming and settled living is commonly considered an advance for humanity, but the new conditions appear to have adversely affected longevity, precipitating a substantial decline to about 20 years [*12*]. Mortality profiles thereafter remained relatively stable (as late as 1667 average life expectancy in London was estimated to have been 18) [*2*] and it seems likely that from the Neolithic Revolution until the late 18th century, expectation of life in "civilized" nations seldom or never exceeded 25 years. Thereafter, technological breakthroughs in food production, manufacturing, transportation, trade, communications, and energy generation gave rise to what economists call *modern economic growth* [*13,14*]. A major component of this transformation was sustained increase in per capita income, a measure that reflects human productivity and determines average purchasing power. In Britain, per capita income doubled between 1780 and 1860, and then multiplied a further sixfold between 1860 and 1990 [*15*]. Shelter, transportation, clothing, and food became progressively less expensive in terms of the time and energy necessary to obtain them.

At the most basic level, increased human productivity equates to more efficient food energy acquisition: more calories are gained for a given effort. This improved efficiency makes more energy available for bodily requirements other than physical work.

		Physical Energy Expenditure
		+
		Resting Metabolism
Food Energy Intake	=	Specific Dynamic Action
		Pathogen Resistance
		Growth
		Reproduction
		Energy Storage

Of these, the most important, vis-à-vis life expectancy, has been pathogen resistance [*16,17*]. The Industrial Revolution so significantly enhanced productivity per hour of human effort that human health improved even as population soared, thereby defying Malthusian expectations. This was an unprecedented development.

[3] Stroke, coronary heart disease, diabetes, chronic obstructive pulmonary disease, lung cancer, female breast cancer, cervical cancer, colorectal cancer, and chronic liver disease/cirrhosis.

[4] Imperfect, but the best available surrogates for prehistoric Stone Agers.

Ten thousand years earlier the comparably significant Agricultural Revolution increased productivity per unit of land area, making more total food energy available so that population growth accelerated. However, productivity per hour of effort actually may have diminished: around this time average final height declined while skeletal markers of infection and nutritional stress became more common [*18,19*]. Modern economic growth reversed the agricultural era's negative effects on individual energy balance, thus promoting biological phenomena, such as greater adult stature, earlier puberty, and increased energy storage (as adipose tissue), which have characterized the past 200 years. The new energy balance also extended human life expectancy, another of the past two centuries' bio-phenomenal hallmarks. Greater energy availability enhanced potential for repairing the effects of trauma, meeting the energetic requirements of childbearing, and combating the onslaught of harmful microbes. Because infectious diseases had previously been the paramount causes of mortality, the latter was of special importance for longevity [*16,17*].

Life expectancy was negatively affected by population shifts from the countryside to urban areas where crowd diseases were prevalent. Also, increases were observed earlier among the upper classes, which received a greater proportion of the Industrial Revolution's initial benefits [*13*]. Nevertheless, between 1700 and 1900, overall British life expectancy increased 34 years—from 18 to 52 [*2,16*]. Between 1890 and 1990 real income (inflation adjusted) for the poorest 20% of households increased 19-fold so that the health effects of industrialization have become more equitably distributed [*13*], with the result that average life expectancy now exceeds 75 years in many Western nations.

Although they obviously make an irreplaceable contribution to individual health and quality of life, there is surprising consensus "that specific therapeutic medical treatments have had little impact on mortality reduction" [*20*]. On the other hand, there is increasing agreement that public health achievements such as better sanitation (purer water, adequate sewage disposal), safer food, effective systems of quarantine, and immunizations have exerted a critically important influence on longevity. Whether economic considerations or public health measures have had greater impact is disputed [*16,20,21*], but their effects have clearly been complementary, especially since the mid-19th century. It is the combination of these societal developments rather than individual lifestyle choices which have led to an average life expectancy twice that of any prior human society.

GENETIC CHANGE SINCE AGRICULTURE

During the past 10,000 years there have been approximately 400 to 500 human generations. Given sufficient selective pressure, this many generations afford ample opportunity for very significant genetic evolution. For example, Wrangel Island mammoths, isolated from the Siberian mainland by rising sea levels at the end of the last Ice Age became dwarfed (to about one-third the size of their ancestors) over a period of "only" 5,000 to 7,000 years [*22*]. In light of this and similar documented instances of rapid mammalian evolution, important post Stone Age changes in the human gene pool cannot be excluded. Perhaps these have adapted us for the conditions of life in affluent Western nations.

However, from the standpoint of evolutionary theory an expanding population, increasing interregional travel, and cultural innovations capable of dampening environmental variability should reduce the likelihood of genetic novelties becoming established [*23*]. That is, they should retard the rate of genetic evolution. Respected geneticists [*24*], paleoanthropologists [*25*], biologists [*26*], and evolutionary theorists [*27*] concur that, genetically, contemporary humans differ little from our Stone Age ancestors. This contention can be tested by comparing the genetic makeup of existing populations. If agriculture and "civilization" have significantly altered the human genome, groups like the Kalahari San, arctic Inuit, and Australian Aborigines, whose ancestors were hunter-gatherers until recent centuries, should differ, genetically, in some systematic, identifiable way from Near Easterners, Chinese, and New Guineans, whose ancestors adopted farming millennia ago. There is no evidence for any such distinction [*28*]. While there is genetic variation between different human populations, some of which affects disease susceptibility, little of this variation can be ascribed to the effects of cultural developments during the past ten millennia. (Lactose and gluten tolerance, as well as several hemolytic anemias, are possible exceptions.) There has been ample time for important changes in the human gene pool since the Neolithic Revolution, but comparative genetic data provide compelling evidence against the contention that long exposure to agricultural and industrial circumstances has distanced us, genetically, from our Stone Age ancestors.

THE ENVIRONMENT OF EVOLUTIONARY ADAPTEDNESS

This infelicitous term designates that evolutionary time segment during which selective pressures operating in our ancestors' physical and psychological environments led to the appearance of distinguishing modern human traits. Of course past circumstances varied with time period and geographical location and this inconstancy has been held by some to invalidate any "Paleolithic prescription." If there was no one universal ancestral lifestyle pattern, how can past experience provide a model for health recommendations in the present?

The answer is that differences between ancestral environments across time and space were minor compared with their essential similarities, especially when contrasted with human experience in the affluent present. Whether Stone Agers lived in the arctic or the tropics, vigorous physical exertion was essential; for foragers living 500,000 or 50,000 years ago food was derived from naturally occurring vegetation and wild game. Age at first pregnancy, nursing patterns, and birth intervals varied little among prehistoric hunter-gatherers but, in general, differed markedly from the reproductive experiences of most women in contemporary affluent nations [*29*]. If the social organization of recently studied foragers can be extrapolated into the past—which is probably valid at least back to the appearance of behaviorally modern humans—nomadic Stone Agers lived in small groups whose members knew each other intimately, not in megapolitan aggregations of strangers and casual acquaintances. Politically they were egalitarian, not hierarchical [*30*], and economically there must have been more equitable resource allocation than at any time subsequent to the appearance of chiefdoms during the Neolithic [*31*].

Ancestral lifeways during the environment of evolutionary adaptedness were indeed heterogeneous, but their core essentials were basically similar and differed strikingly from those of the present. These central characteristics can be utilized to create a legitimate, defensible basis for meaningful research and potentially, for health recommendations.

HUMAN ADAPTABILITY

Humans are among the most adaptable of all mammalian species; indeed, some theorists speculate that an important thrust of our evolutionary trajectory has been toward maximizing that adaptability [*32*]. In addition, our purely biological versatility is extended by culture, the behaviorally modern human capacity to manipulate environment through technology. Given this unique faculty for adjusting to differing conditions, is it not possible, or even likely, that we are acceptably suited to life amid affluent Western conditions? After all, there are now approximately 500 people alive for every single individual living at the end of the Stone Age; an estimated 10 to 15 million 10,000 years ago versus 6 billion at present. Doesn't that indicate how well we've adapted to changing circumstances?

There's no doubt that adaptability has been an important factor in human demographic expansion subsequent to agriculture. Some might question whether our species' explosive growth has been beneficial for the world's biome generally, or even whether it has exerted a positive influence on the individual lives of average humans. Nevertheless, our capacity for physical adaptation and cultural innovation has clearly allowed humans to survive and multiply in many different environmental settings.

However, this is not to say that our biology operates optimally in all these environments. As a rule, biological organisms are healthiest when their life circumstances most closely approximate the conditions for which their genes were selected. In many cases our intrinsic adaptive capacity allows us to accommodate deviations with little immediate effect on health. But ultimately, beyond currently undefined limits, an individual organism's adaptation may sacrifice future health for short-term survival. Conditions tolerable or even beneficial in early life may lead, eventually, to chronic degenerative diseases.

Suboptimal circumstances take varying time periods to induce ill effects. Lack of oxygen is lethal in minutes, scurvy develops after months of inadequate vitamin C intake, and insufficient dietary calcium commonly takes decades to produce clinical osteoporosis. Deviations from our ancestral lifestyle—in nutrition, exercise, reproduction, etc.—can produce ill effects during early life, but many individuals appear outwardly healthy well into middle adulthood and even beyond. However, if preagricultural lifeways are truly those for which humans remain genetically programmed, we can expect that, despite our adaptability, most of us will eventually have to pay the piper. The evolutionary hypothesis proposes that chronic degenerative diseases are the price.

CONCLUSION

These counterarguments are important because the intuitive appeal of the issues they address sometimes biases consideration of evolutionary health promotion's real nature and possible significance. Proponents of this emerging discipline do not, necessarily, oppose modern economic growth and are certainly not against the achievements of medicine and public health. Their argument is that, in the area of individual lifestyle choices relative to prevention of chronic degenerative disease, the pertinent aspects of Paleolithic experience [*33*] should be considered an attractive, potentially fruitful candidate paradigm that deserves discussion and research evaluation. No theory can become a paradigm until investigation and hypothesis achieve accord, but any rejection of evolutionary health promotion should be based on its falsification by experiment or because another theory fits better with known facts—not because of unjustified preconceptions about genetic evolution since agriculture, human adaptability, nor the heterogeneity of Paleolithic environments. And certainly not because we live longer than did Stone Agers. Contemporary longevity reflects modern economic structure in conjunction with public health measures. It is neither an endorsement of our current individual lifestyle choices nor a valid argument against evolutionary health promotion.

REFERENCES

1. Hahn RA, Teutsch SM, Rothenberg RB, Marks JS. Excess deaths from nine chronic diseases in the United States, 1986. JAMA 1990;264:2654–9.
2. Lancaster HO. *Expectation of life: a study in the demography, statistics and history of world mortality.* New York: Springer-Verlag, 1990:25.
3. Eaton SB, Konner M, Shostak M. Stone Agers in the fast lane: chronic degenerative diseases in evolutionary perspective. Am J Med 1988;84:739–49.
4. Eaton SB, Eaton SB III. The evolutionary context of chronic degenerative diseases. In: Stearns SC, editor. *Evolution in health and disease.* Oxford: Oxford Univ Press, 1999:251–9.
5. Shephard RJ, Rode A. *The health consequences of modernization: evidence from circumpolar peoples.* Cambridge: Cambridge Univ. Press, 1996:101–8.
6. Howell N. *Demography of the Dobe !Kung.* New York: Academic Press, 1979:30.
7. Hill K, Hurtado AM. *Ache life history. The ecology and demography of a foraging people.* New York: Aldine De Gruyter, 1996: 193,194,206.
8. Lindeberg S, Lundh B. Apparent absence of stroke and ischaemic heart disease in a traditional Melanesian population: a clinical study in Kitava. J Int Med 1993;233:269–75.
9. Trowell HC, Burkett DP, editors. *Western diseases: their emergence and prevention.* Cambridge, MA: Harvard Univ. Press, 1981:xiii–xvi.
10. Headland T. Population decline in a Phillipine Negrito hunter-gatherer society. Am J Hum Biol. 1989;1:59–72.
11. Blurton Jones N, Smith L, O'Connell J, Hawkes K, Kamusora CL. Demography of the Hadza, an increasing and high density population of savanna foragers. Am J Physiol Anthropol 1992; 89:159–81.
12. Angel JL. Health as a factor in the changes from hunting to developed farming in the eastern Mediterranean. In: Cohen MN, Armelagos GJ, editors. Paleopathology at the origins of agriculture. New York: Academic Press, 1984:51–73.
13. Fogel RW. *The fourth great awakening and the future of egalitarianism.* Chicago: Univ. Chicago Press, 2000:48,137–75.
14. Kuznets S. *Modern economic growth: rate, structure, and spread.* New Haven: Yale Univ. Press, 1966:8–16.
15. Landes DS. *The wealth and poverty of nations.* New York: Norton, 1998:194.
16. McKeown T, Brown RG, Record R. An interpretation of the modern rise of population in Europe. Population Studies 1972;26: 345–82.
17. Scrimshaw NS. Infection and nutrition: synergistic interactions. In: Kiple KF, Ornelas KC, editors. *The Cambridge world history of food, Vol. 2.* Cambridge: Cambridge Univ. Press, 2000:1397–1411.
18. Cohen MN, Armelagos GJ. Editor's summation. In: Cohen MN, Armelagos GJ, editors. *Paleopathology at the origins of agriculture.* New York: Academic Press, 1984:585–601.
19. Larsen CS. Dietary reconstruction and nutritional assessment of past peoples: the bioanthropological record. In: Kiple KF, Ornelas KC, eds. *The Cambridge world history of food, Vol. 1.* Cambridge: Cambridge Univ. Press, 2000:13–34.
20. Kim JM. Nutrition and the decline of mortality. In: Kiple VF, Ornelas KC, eds. *The Cambridge world history of food. Vol. 2.* Cambridge: Cambridge Univ. Press, 2000:1381–9.
21. Szreter S. The McKeown thesis. J Health Services Res Policy 2000;5:119–21.
22. Carroll RL. Rates of evolution. In: Carroll RL, ed. *Patterns and processes of vertebrate evolution.* Cambridge: Cambridge Univ. Press, 1997:52, 72–80.
23. Tattersall I. *Becoming human.* New York: Harcourt Press, 1998:239.
24. Neel JV. *Physician to the gene pool.* New York: Wiley, 1994:302, 315.
25. Klein RG. *The human career.* Chicago: Univ. Chicago Press, 1999: 549.
26. Wilson, EO. *Consilience.* New York: Knopf, 1998:171, 182, 296.
27. Gould SJ. *The panda's thumb.* Toronto: McLeod, 1980:83.
28. Cavilli-Sforza LL, Menozzi P, Piazza A. *The history and geography of human genes.* Princeton: Princeton Univ. Press, 1994: 73–83.
29. Eaton SB, Eaton SB III. Breast cancer in evolutionary perspective. In: Trevathan WR, Smith EO, McKenna JJ, eds. *Evolutionary medicine.* Oxford: Oxford Univ. Press, 1999:429–42.
30. Boehm C. *Hierarchy in the forest. The evolution of egalitarian behavior.* Cambridge, MA: Harvard Univ. Press, 1999:31–8.
31. Diamond J. *Guns, germs, and steel.* New York: Norton, 1997: 265–92.
32. Schlicting CD, Pigliucci M. *Phenotypic evolution. A reactive norm perspective.* Sunderland, MA: Sinauer, 1998:51–84.
33. Eaton SB, Strassmann BI, Nesse RM, et al. Evolutionary health promotion. Prev Med, doi:10.1006/pmed.2001.0876.