

REVIEW

Biological and Clinical Potential of a Palaeolithic Diet

STAFFAN LINDEBERG MD PhD,¹ LOREN CORDAIN PhD² AND
S. BOYD EATON MD³

¹Department of Medicine, Lund University, Sweden, ²Department of Health and Exercise Science, Colorado State University, Fort Collins, Colorado, USA,

³Departments of Radiology and Anthropology, Emory University, Atlanta, Georgia, USA

Abstract

Purpose: To explore the possibility that a Palaeolithic diet, i.e. one that corresponds to what was available in any of the ecological niches of pre-agricultural humans (1.5 million–10,000 years BP), is optimal in the prevention of age-related degenerative disease.

Design: Literature review.

Materials and Methods: Between 1985 and December 2002, more than 200 scientific journals in medicine, nutrition, biology and anthropology were systematically screened for relevant papers. Computer-based searches and studies of reference lists in journals and books provided a vast number of additional papers.

Results: Increasing evidence suggests that a Palaeolithic diet based on lean meat, fish, vegetables and fruit may be effective in the prevention and treatment of common Western diseases. Avoiding dairy products, margarine, oils, refined sugar and cereals, which provide 70% or more of the dietary intake in northern European populations, may be advisable. Atherosclerosis is highly dependent on dietary manipulation in animal experiments. Atherogenic dietary factors include fat (any type) and casein, and hypothetically cereals. Stroke, ischaemic heart disease and type 2 diabetes seem largely preventable by way of dietary changes in a Palaeolithic direction. And insulin resistance, which may have far-reaching clinical implications as a cause of unregulated tissue growth, may also respond to an ancestral diet.

Conclusions: Lean meat, fish, vegetables and fruit may be optimal, rather than a strictly vegetarian diet, in the prevention of cardiovascular disease, diabetes and insulin resistance.

Keywords: Palaeolithic diet, evolutionary medicine, nutrition, health promotion, cardiovascular disease, metabolic syndrome.

INTRODUCTION

Nutritional advice aimed at the long-term prevention of common Western diseases is subject to considerable uncertainty. In epidemiology, one type of bias arises when a studied factor, say wine drinking, does not prevent the disease with which it is inversely related, say ischaemic heart disease, because it happens to co-vary with a factor that was not included

This paper was presented at the British Society for Allergy, Environmental and Nutritional Medicine one-day meeting on 1 November 2002.

in the analysis, e.g. a low intake of milk. This problem is called confounding. Another source of bias is insufficient variation: if the range of sodium intake within a population is small, a true health effect can escape detection, especially if the assessment of sodium intake is imprecise.

Molecular biology affords a potential basis for nutritional advice, but its applicability to environmental health hazards is complicated. Dietary intervention trials constitute an ultimate test, but they must be appropriately blinded for reliability. In addition, there is a considerable risk of publication bias when large trials are lacking, which is often the case [1]. In view of these limitations, other evidence pertaining to healthy lifestyles is desirable. One logical candidate is evolutionary biology.

EVOLUTIONARY ASPECTS OF NUTRITION

Darwin's theory of evolution has had an enormous impact on the biological sciences, but surprisingly little on medicine and nutrition. Recently, the multidisciplinary field of evolutionary medicine has been established. Interested investigators and scholars analyse health and illness from an evolutionary perspective and consider whether our departure from the hunter-gatherer lifestyle may contribute to contemporary health problems [2, 3].

The basic notions are very simple: foods are probably appropriate for any given species if they were regularly consumed during most of its prior evolution, in our case the hunter-gatherer diet. Plants protect themselves with toxins and bioactive substances, xenobiotics, directly aimed at insects and herbivores [4]. Highly specialized herbivores often show adaptive traits in digestion or metabolism as part of the 'chemical warfare' between plants and animals. Prehistoric human hunter-gatherers may have limited these problems by choosing parts of plants that had low concentrations of xenobiotics (fruits, berries, nuts, leaves), by consuming a large variety of vegetable foods and by deliberate avoidance of the most dangerous plant species [5].

PALAEOLITHIC DIET

Several authors have suggested that reversion to the original Palaeolithic human lifestyle (1.5 million–10,000 years BP) would prevent some of the age-related degenerative diseases in Western societies [6–19]. The available food staples during the Palaeolithic period may have been meat, fish, shellfish, leafy vegetables, fruit, nuts, insects and larvae in varying proportions [20]. Because tubers often require cooking for their starch to be digestible [21], their routine consumption may date to the later portion of this period. The intake of dairy products, margarine, oil, sugar and cereals, which supply 70% of the dietary energy in Sweden today [22], was negligible. Irrespective of the specific proportions of meat and vegetables, any prehistoric hunter-gatherer diets would have been very different from those of contemporary humans with regard to their nutritional value.

Lean meat is satiating because of its high protein content [23–25] and has beneficial effects on serum lipids [26–32]. Fruit and vegetables are rich in minerals, vitamins and soluble fibre, and do not increase blood glucose as much as typical carbohydrate-rich foods in the West, i.e. their glycaemic index is relatively low [33]. Nuts may also be beneficial because of their high concentration of minerals and soluble fibre and their high monounsaturated low saturated fatty acid ratio [34]. In one trial, serum lipid improvement after a diet based on fruit, nuts and vegetables was similar to that achieved by medical treatment with statins [35]. The diet in that trial may be regarded as a vegetarian Palaeolithic diet.

Calcium content is sometimes high in Palaeolithic diets. This is because of the high calcium density (mg per unit of energy) in vegetables, especially leafy vegetables. However,

large amounts are necessary in order to achieve recommended dietary allowances. Other nutritional characteristics of Palaeolithic diets include a low omega 6:omega 3 fatty acid ratio [36] and a low sodium content.

ATHEROSCLEROSIS

Atherosclerosis is part of the typical ageing process in Western societies today, where many individuals are affected from an early age [37, 38]. Other free-living mammals are apparently spared this condition unless they are fed a diet not available in their natural habitat [39]. Atherosclerosis promotion and regression in animal experiments is highly responsive to dietary manipulation, far more than to psychological stress, physical inactivity or smoking alone [40–42].

Fat intake is not the only dietary factor that affects the atherosclerotic process in animal experiments. Many trials have shown that casein promotes atherosclerosis more than soy protein [43], and one trial suggested that meat proteins are less atherogenic than soy protein and casein [44]. Hence, meat may be less atherogenic than soy beans, low fat milk and high fat milk, in that order. The unfavourable impact of milk protein on serum cholesterol and atherosclerosis is commonly referred to as an effect of ‘animal protein’. However, the studies cited suggest that the term ‘animal protein’ is insufficiently specific and should be abandoned.

There is some evidence that cereals promote atherosclerosis. This was suggested long ago by Fiennes [45] who noted that graminivorous birds (sparrows, ostriches and others), as well as mammals who are specialized seed eaters (rats, mice), are resistant to atherosclerosis when they are fed a cereal-based atherogenic diet, while non-seed eaters (parrots, primates, pigs, hamsters, etc.) are not. There are several reasons why grains may be atherogenic.

Among the more fascinating suspects is the group of xenobiotics known as plant lectins [46, 47]. Wheat lectin (wheat germ agglutinin) increases intestinal permeability [48], enters the circulation [49], activates platelets and cell adhesion molecules such as PECAM-1 [50], binds to macrophages and smooth muscle cells in the arterial wall [51, 52], and also binds to receptors that are normally activated by insulin and insulin-like growth factor-1 [53, 54]. Although each of these interactions is relevant to the atherosclerotic process, the health consequences of dietary wheat germ agglutinin are largely unknown. One of the most atherogenic fats is peanut oil [55], but it becomes much less atherogenic after peanut lectin has been removed from the oil [56].

In addition, cereals are low in vitamin C, zinc, selenium, flavonoids, carotenoids, vitamin B12, folic acid, omega 3 fatty acids, potassium, biotin, vitamin D and taurine, while the bioavailability of magnesium and vitamin B6 is low [57]. Each of these nutrients has been suggested as preventing atherosclerosis.

STROKE AND ISCHAEMIC HEART DISEASE

Available evidence suggests that obesity, hypertension, diabetes and cardiovascular disease are rare or unknown in populations preserving traditional subsistence and lifestyle patterns [58]. Regarding ischaemic heart disease, the evidence is particularly solid, but even stroke has been convincingly related to urbanization in East Africa during the twentieth century. Three consecutive surveys in Uganda from 1920 onwards documented the emergence of stroke from initial absence to being the most common neurological disorder as urbanization progressed in the region [59–61]. The same phenomenon is being repeated in Papua New Guinea, where stroke, formerly unknown, has become one of the leading neurological causes of death and disability (I. Kevau, unpublished observations).

A Palaeolithic diet may prevent stroke because of its low sodium content [62, 63], its

large amounts of vegetables and fruit [64, 65], and/or because of its generous content of protein, folic acid, vitamin B6, vitamin B12, potassium, magnesium and vitamin C [64, 66–73].

Among hunter–gatherers, subsistence horticulturalists and traditional nomads, blood pressure and body mass index have consistently been low, with no or little age-related increase [74–86]. Insulin sensitivity appears to have been high, as reflected by glucose tolerance testing [87–89]. Serum cholesterol has been very low in some populations [78, 90–93], but not in others [94–99].

The cardiovascular risk factors in hunter–gatherers (males aged 40 years) were:

- insulin response to oral glucose 40% lower than in Westerners;
- body mass index 20 (25 in Sweden);
- no overweight, slim waist;
- blood pressure 105/65 (130/80 in Sweden).

In our health survey of the people of Kitava, Trobriand Islands, Papua New Guinea, we found the population to be free from overweight, hypertension, hyperinsulinaemia, ischaemic heart disease, stroke and malnutrition [100–102]. Signs of the metabolic syndrome were conspicuously absent, although serum lipids were less favourable [101–104]. The influence of imported food was negligible and staple foods were tubers, fruit, coconut, fish and vegetables [105]. Total fat intake was low (approximately 20% of dietary energy, E%) and fibre intake was high, but the estimated intake of saturated fat from coconut was similar to that in Sweden (17 E%) [105]. Accordingly, considerable overlapping of serum cholesterol was found between Kitava and Sweden: 40% of Kitavan males and 60% of Kitavan females had low-density lipoprotein cholesterol $\geq 3.4 \text{ mmol l}^{-1}$ [101]. Furthermore, serum high-density lipoprotein cholesterol and triglycerides were similar to Swedish levels.

Smoking rates were 75% in males and 80% in females, supporting the notion that smoking alone may not be sufficient to cause cardiovascular disease [106–108].

Compared with non-smokers, smokers had lower high-density lipoprotein cholesterol, apolipoprotein A1 and triceps skinfold thickness (TSF), and higher serum triglycerides, while fibrinogen did not differ.

The estimated level of physical activity was 1.7 multiples of the basal metabolic rate, which is slightly higher than the levels of sedentary Western populations. Our survey methods did not include any assessment of psychosocial factors.

TYPE 2 DIABETES

Fasting serum glucose levels among Kitavans averaged two standard deviations below the Swedish means, and no Kitavan had glucose above 6.1 mmol l^{-1} [102]. Serum insulin and leptin were also low and decreased with age in Kitava as opposed to the Swedish pattern [102, 104]. The mean insulin concentration in 50–74-year-old Kitavans was 50% lower than in Swedish subjects. Age, body mass index and, in females, waist circumference predicted Kitavan insulin levels at age 50–74 years remarkably well when put into the Swedish multiple linear regression equations. These findings indicate a virtual absence of type 2 diabetes.

Long-term investigations of Palaeolithic diets in manifest diabetes are not yet available. O’Dea [13] studied a group of diabetic Australian Aboriginals who returned to a Palaeolithic lifestyle for a 7-week period. Improvements were dramatic for most measures, particularly those related to overweight and insulin resistance. The effects of a low glycaemic load (low glycaemic index and/or low carbohydrate content) and low energy density seem to benefit such patients. High protein intake may have a negative impact on renal function, but the magnitude of this effect is debatable [109–112]. A few animal studies suggest that protein quality may be of importance [113]. In one experiment on the Zucker

rat, casein accelerated impaired renal function as compared with soy protein [114], and in another rat study, both casein and soy protein caused decreased insulin sensitivity, while fish protein did not [115].

INSULIN RESISTANCE

The apparent absence of cardiovascular disease and diabetes among the Kitavans and other traditional populations seems largely to be explained by the absence of abdominal overweight and insulin resistance. Decreasing insulin sensitivity with increasing age, which is typical in Westernized populations, should probably not be regarded as normal biology [102].

The consequences of insulin resistance may reach far beyond the metabolic syndrome and cardiovascular disease. Cordain [116–118] has suggested that compensatory hyperinsulinaemia alters a number of endocrine pathways and favours the growth of various tissues with clinical consequences including polycystic ovary syndrome, acne vulgaris, epithelial cell cancers, and myopia, as well as the secular trends for increased stature and earlier puberty. Specifically, chronically elevated plasma insulin levels result in increased circulating concentrations of insulin-like growth factor-1 and reduced concentrations of insulin-like growth factor binding protein-3 (IGFBP-3). Because circulating IGFBP-3 may adversely influence retinoid receptor activity, hyperinsulinaemically mediated alterations in IGFBP-3 will reduce the transcription of antiproliferative genes in a variety of cells.

SICK POPULATIONS AND SICK GENES

Urbanization has had a strong impact on blood glucose among four representative African populations [119]. These and other migrant studies indicate that virtually 100% of individuals develop higher glucose values after migration than controls who have maintained a traditional lifestyle. Genetics and environment thus work together, not independently [120], or, in the words of Rose, ‘the answer to “Why does this particular individual in this population get this disease?” is not necessarily the same as the answer to “Why does this population have so much disease?”’ [121]. The two approaches are not theoretically independent, even if they compete for funding.

Humans of European descent are as a group slightly less prone to diabetes and insulin resistance [122–124], which indicates the presence of some negative selection pressure after the rise of civilization. Allen and Cheer [122] have suggested that this could be diabetes related to milk consumption, a notion supported by studies in calves who become more insulin resistant when milk supplies are increased [125].

Because of these apparent ethnic differences in susceptibility, the consequences of insulin resistance seem especially harmful for non-Europeans. In Singapore, an astonishing 82% of the Chinese population have myopia [126] and in a random sample of Indian women in Britain the prevalence of polycystic ovary syndrome was 52% (110/212) [127]. Both of these populations have a high prevalence of insulin resistance. Likewise, the median menarcheal age of 107 girls adopted from India by families in Sweden was 11.6 years, which was significantly lower than for Swedish girls or for girls in India [128]. Five girls had menarche before the age of 9 years, the earliest at 7.3 years.

OSTEOPOROSIS

The large international variation in incidence rates of osteoporotic fractures suggests that additional lifestyle factors are at hand apart from those generally discussed (physical

inactivity, low calcium intake, vitamin D deficiency, weight loss, smoking and alcohol). The original Palaeolithic lifestyle included beneficial factors such as much outdoor walking on a low latitude, high calcium bioavailability owing to a low intake of cereals and beans [129], and low urinary losses of calcium because sodium intake was low [130, 131]. Sometimes calcium intake was high from green and leafy vegetables. These are also rich sources of potassium and, hence, they have an alkalizing effect which retards urinary calcium loss [132–139].

The optimal protein intake for bone strength is a matter of dispute. In recent years, several studies have suggested that protein intake in many elderly Westerners is too low for optimal bone density to be maintained [140–146]. This contrasts with the earlier hypothesis that high protein intake promotes osteoporosis. It is of some relevance that the author of the most cited paper favouring that hypothesis no longer believes that protein is harmful to bone [142]. Nevertheless, there is strong evidence that a net acid load (resulting from high dietary protein and cereal grain intake) increases renal excretion of calcium [132–139, 147]. However, as cheese, cereals, beans and added salt were not included in the Palaeolithic diet, while fruits and vegetables exceeded current intake levels, the net effect may be beneficial [118, 148].

Another matter of controversy is whether protein quality is important [146, 149]. Most studies suggest that, compared with omnivores, bone mass in vegetarians is lower [150–152] or not different [153–155], while only one study showed higher bone mass among vegetarians [156]. Some studies suggest that soy protein prevents osteoporosis, but in the relevant experiments, the control protein was casein [157–159]. In one study, soy protein lowered bone mass and raised levels of parathyroid hormone in pigs in comparison with fish meal [160].

According to the ‘lipid hypothesis of osteoporosis’, dyslipidaemia and oxidized low-density lipoproteins contribute to osteoporosis [161]. Also, insulin-resistant subjects and patients with diabetes have brittle bones despite an increased bone volume [162–168]. Diet-induced insulin resistance in rats increases fracture tendency without lowering bone density [169, 170]. These findings underscore the fact that bone strength is not solely dependent on bone volume [171]. Thiazolidinediones, drugs that enhance insulin sensitivity (by stimulating the nuclear receptor PPAR γ), seem to inhibit osteoclastic activity and, hence, suppress bone resorption [172].

CONCLUSION

Lean meat, fish, leafy/green vegetables and fruits are advisable as health promoting because of our long pre-agricultural ancestral experience during which such foods fuelled human evolution. Dairy products, cereals, beans, salt, separated fats and refined carbohydrates, including sugar, are ‘new’. Increasing evidence indicates that their inclusion in the human diet can have adverse effects on health, especially with regard to promoting chronic illnesses. Further investigation, especially in human subjects, is needed, but the theoretical underpinning of Palaeolithic nutrition is more robust than that of any other proposed health-promoting dietary regimen.

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