

Review Article

Nutrition and the extremes of life: dilemmas and enigmas of advanced old age

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Introduction

Humans cannot live beyond 120 years; they were never meant to live beyond 40 years.

Human evolution (in the wild) to technological eruption (domestication of plants, animals and man): the odyssey of humankind

The odyssey of Odysseus lasted for 20 years, until he returned – older and seasoned – to the shores of Ithaca as the sole survivor of his troupe. The odyssey of humankind has lasted 200 000 years (some estimate twice that), from the time that hominids began to walk erect, use tools, and compete for survival with the biodiversity of plants that could be their food or their poison and animals that could be their prey and their predators. At the turn of only the third millennium after the birth of Christ (and the 200th to 400th of ‘human’ history), we have emerged from our odyssey as a species that, like Odysseus, is a survivor; matured and older and wiser. We are wise – and clever – enough to have unravelled the code of the human genome in 2000. But, at the same time, we are destined both to understand our genetic heritage, and not to move too actively beyond it.

From hunter-gatherer to pastoralist to agriculturalist to industrialist to informaticist

Food is an absolute necessity and its pursuit characterises the essence of all species. Eat to live, live to reproduce, reproduce to maintain the species. Canines (carnivores) are hunters. Ungulates (herbivores) are grazers. Humans are omnivores, characterised as hunter-gatherers. Recently, the anthropological debate about how much of our food was from the hunt (meat) and how much was from the gather (plants) has been joined.^{1,2} For all but the last 40 millennia, this was the exclusive lifestyle for all of humanity.

Before the ‘domestication’ of the human species by its own technology in recent centuries, societies traditionally have not had many elders in their midst and very few of the oldest old. The functional decline of tissues and organs with age is a reality. On the plains of Africa, the hunting predators are not without their own evolutionary wisdom. It is the slowest zebra or the least formidable cape buffalo that

becomes the prey of the lioness. Usually it is age that determines who runs away and who is devoured. Undomesticated man played within the same rules. There is a classic wartime film about a suicide mission by the US Navy entitled, *They Were Expendable*. In the same sense, when the tribe was in danger from predators on the hunt or warriors from another clan, the weakest adults could become the sacrifices for the reproductive core to escape and survive.

Some 40 000 years ago, domestication began. It began with the domestication of wild grazing beasts to form herds of dairy animals, and wild canines to help tend them, but this made the ‘wilds’ less wild, and the pastoralist marked the (auto)domestication of humans themselves. Humans were still migrant but carried their milk sources with them. They also hunted and gathered on the side. Ten thousand years ago, domestication of grass seeds began, first with wheat and barley,³ then 7000 years ago with rice and maize. To be a subsistence agriculturalist, one now had to become settled and territorial as the fields were staked out and cultivated. Two hundred years ago, the Industrial Age began with the harnessing of energy sources, and the same energy used in the fields led to agroindustry. Now for all humans to eat, not all humans had to work in food production. With the invention of the transistor in the 1950s and the silicon chip in the 1980s, communication of information over vast distances became possible. Hence, over the millennia of evolution, humankind’s lifestyle has marched from chasing the mastodon into a pit to surfing the worldwide web on a computer.

Demographic considerations

In a biological sense, we know intuitively and empirically that not all persons in the seventh decade and beyond are a

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homogeneous mass. The National Institute of Ageing of the USA, when it emerged as a separate institute, began to characterise the stages of advanced age as: (i) the 'young' old (65–74 years); (ii) the 'old' (75–84 years); and (iii) the 'old' old (85 years and beyond). The investigator was at peril if his or her grant proposal failed to recognise these distinctions.

There are six billion people in the world. Of these, it is estimated that 300 million are over 60 years of age, the minimum criterion to be classified as elderly. At the turn of the millennium, there were 100 000 centenarians worldwide, with one-quarter of them living in the United States. The pace of mortality improvement for this age-group has accelerated in the last half of the 20th century, especially notable in Japan. In developing countries, for 'younger' long-term survivors (i.e. those of 80 years), the population is expected to increase by almost 400% between 1980 and 2020. Today, for a woman who reaches 80 years, her median expected survival is another 9 years to reach 89 years. In Victorian times in Great Britain, a 5-year-old child had only a 25% chance of having a living grandfather; today this is almost universal. In fact almost 50% of children have a great-grandfather who survives through their early childhood.

Intergenerational tensions and value judgements

The emergence of a senior segment of the demographic pyramid (i) provides the potential intergenerational conflicts in aspirations, and (ii) raises physiological implications for the determination of strategies for quality of life (maintenance of functions, compression of morbidity) versus quantity of life (extension of longevity, but without health). The elderly need (i) access to resources; (ii) space for themselves, within the family and in society; and (iii) health care. The other generations (children, young and middle-aged adults) need (i) access to resources; (ii) space for themselves, within the family and in society; and (iii) health care. When there are constraints in any of these domains, the potential for tension and conflict presents itself.

Various ideals of civilised culture

- All men are created equal...
- ...inalienable rights,...life, liberty and the pursuit of happiness...
- Love thy neighbour as thyself...
- Honour thy father and thy mother, that thy days may be long...

As socialised individuals, we are imbued by ideals such as those listed above. Even with the undercurrents for intergenerational tension, these ideals mitigate against hostilities.

What is interesting in the breach across the elder and younger generations is discordance in the views of what should be the goal of life after 60 or 80 years. Should it be the maximum length, the highest quality, or should it be 'God's will'? These are value questions, but the strategic and tactical decisions, even for provision of a specific diet to the elderly, are cloaked in value decisions.

As is evident, ethical, economic and biomedical research issues are presented in the question of the goals and guidelines for diet of the elderly in both its social (elders in society) and individual (care of the individual elder) context.

Diet is both a source of nutrients and a set of 'exposures'

We eat because we are hungry and we drink because we have thirst. These basic instincts are driven by the requirements of the organism to have nutrients, one of the most important of which is water. These organic and inorganic chemicals, classified as nutrients, have essential beneficial functions. In hunter-gatherer societies, tribes eat and drink what is in their reach. Civilization has added the hedonistic dimension of pleasure to meals in so far as foods and beverages with better appearance, taste and flavour, texture and temperature are more appealing and sought after. Combined with a predictable supply of items, culturally based cuisines have emerged. Meals and mealtime have also taken on a social dimension of household interaction around the table or the cooking pot.

What determines the supply of nutrients to the body is a series of interrelated factors. These begin with the intrinsic content of nutrients in the selected foods and beverages after processing, at the point of consumption. The extent of absorption of nutrients is governed in part by intrinsic barriers and host regulation. The form of the nutrient in the food itself and the accompanying substances in the meal can also enhance or inhibit delivery to the body. Disease of the intestinal tract can reduce digestion of foods and the absorption of nutrients. Once absorbed, the persistence of a nutrient in the body is governed by the mechanism of its conservation and retention. Renal disease can lead to both excessive retention and increased wastage of certain nutrients. For other nutrients, the states of retention can be influenced by the rates of secretion of bile, pancreatic juice or intestinal fluid, which are the routes of disposal for some micronutrients.

An important additional consideration, emerging from epidemiological research on diet and health associations, is that not all of the influence of food and beverages on human vitality is related to their role as a source of nutrients. The chemicals that are nutrients have other actions, aside from their functions, that influence the health of the organism. Other constituents of the diet (non-nutrients), such as xanthophyll carotenoids, phytosteroids, flavinoids, phytic acid, tannins (polyphenols) and dietary fibre, have positive actions, while cholesterol, anti-nutrients, toxins and sodium have negative effects. Analysis of the influence of diet on the human body in this dimension can be seen as a series of 'exposures' to the sources of these bioactive constituents. Whether they produce or prevent disease, moreover, is strongly influenced by the genetic constitution of the host.

It is widely agreed that the original humans did not suffer the chronic infirmities of contemporary humankind.⁴ In debate is whether their early demise, or the pristine environment, was a determinant. If Cordain *et al.* are correct, and meat was the principle source of calories, the diet was

'atherogenic' and 'carcinogenic' in the extreme.¹ Did the active lifestyle of the hunter-gatherers protect them from the degeneration? Conversely, if Milton *et al.* are correct, then 75% of the gatherer-hunters' fare was from seeds, nuts, roots, berries and leaves.² Did the absence of fat and the fibre and phytochemical content of this regimen confer immunity to chronic disease? If we are to derive wisdom from evolution in terms of reconstituting the degeneration-free era of the original humans, the resolution of the dietary debate has a central importance.

Requirements, recommendations, goals and guidelines for the oldest old

We might have expected that no member of the tribe over 40 years would have escaped the assault of the pack of wolves or survived the last confrontation with the band on the other side of the valley. Our evolutionary instincts might tell us to place the elderly on an ice float and set them adrift, as in the legends of the Eskimos. But our humanitarian and humanistic values dominate, even within the guarded irritations of intergenerational conflicts. Neither evolutionary biology nor demographic experience gives us any first principles for appropriate dietary guidelines and eating pattern recommendations for the oldest old, and they might differ, depending on whether the emphasis be quality (of life) or quantity (of life) goals.

Our humanitarian values make us opt to support the life conditions we find, and there are various options for survivors to reach advanced age. The oldest old may be totally functional, both physically and mentally. This would merit a diet with the energy to support basal and physical energy expenditures, normal protein intakes and the appropriate accompanying micronutrients. Alternately, the person might be debilitated and infirm, with sensory loss, amputation or neurological or musculoskeletal maladies, but not lethally infirm. Their diet should support energy needs at the expenditure permitted, with companion protein and micronutrient intakes. If a metabolic disease, such as diabetes or hypertension, is present, prudent recommendations to contain the glucose and arterial pressure within achievable limits are called for. The individual with a preterminal or terminal condition and with a predictably limited longevity should be fed in a manner that maximizes his or her enjoyment and psychological wellbeing and avoids aggravating the discomfort of the condition. The wisdom of offering life-prolonging regimens or parenteral or enteral support in the terminal state is questionable.

Potential states of the oldest old

- Totally functional and health
- Non-lethally infirm
- With a preterminal or terminal condition

By 2050, half of the Third World elderly will be living in developing countries. Ismail and Manandhar have developed and standardised an approach to assessing and redressing malnutrition in the elderly of developing countries.⁵ I have commented in writing on this effort,⁶ pointing to the explicit

assumptions of the authors: (i) that the only nutritional deviation of interest is undernutrition; (ii) that undernutrition is predominantly primary in nature, due to the conditions of poverty and food insecurity in free-living elderly; and (iii) that persons with low body mass indices (BMI) should be fed until they have non-low BMI. All three assumptions seem questionable. The conventional wisdom from developed country geriatric practice, that weight loss in the elderly relates to underlying pathology, should not be abandoned. Third world elderly get real, chronic diseases too. Moreover, attempting to force the weight back above the 18 kg/m² criterion as a reflex may not be consistent with either maximal longevity or comfort.

Some insights and contributions

Guidelines for recommended diets, as an extension of and adjunct to the US Food Pyramid, were derived by Robert Russell and colleagues working at the USDA Human Nutrition Research Center on Ageing in Boston, USA. They accepted the basic pyramid framework, but went on to revise it based on specific conditions that are more common in elderly populations.⁷ The tendency toward constipation merits increased attention to sufficient water intake and the inclusion of bulking fibres in the diet. Hydration also protects against a greater tendency for the elderly to become dehydrated and to be more susceptible to the ischemic consequences of acute hypovolaemia. Horwath *et al.*, in an article entitled, 'Eating your way to a successful old age, with special reference to older women', have commented on specific modifications that occur with ageing and the cessation of menopause.⁸ It is an adjustment on the nutrient-requirement front, in which they advance the suggestion that iron and vitamin A requirements are lower in advanced age whereas those of calcium, vitamin D, vitamin B₁₂ and vitamin B₆ are higher.

The World Health Organization, in a consultation in Cyprus in 1995, developed the philosophy and concept of Food-Based Dietary Guidelines (FBDG). Wahlqvist *et al.* have interpreted the FBDG concept in reference to diet recommendations specifically for the elderly.⁹ They summarise that 'FBDGs incorporate the nutrient and non-nutrient composition of foods, locally available foods, sustainable food production, food patterns (e.g., traditional diets) and food preparation (cuisine) and their influence on morbidity and mortality levels in populations.' The latent assumption is that rural cuisine is the best pattern for sustained health. However, in the context of the unique (unprecedented) expansion of the elderly, this remains a hypothesis.

The observations of Bernstein and associates suggest that those residents of nursing homes who are more infirm have a more adequate and balanced intake than the more active who serve themselves because the caretaker governs what food is ingested.¹⁰ Self-selection hits farther from the recommended dietary allowance (RDA) mark. Is this bad or good in the big picture?

All of these commentaries are valid and suggest elements for discussion, but without a resolution of the values behind

our individual (clinical) and social (collective) goals for quality of life of the oldest old, they are insights in search of a context.

Summary

Pre-term infants born four months before term have a very low birth weight; in an evolutionary sense, they were never 'meant' to survive through the evolutionary period preceding the technological age. In the same way, evolution failed to contemplate survival to ages 50, 60, 70 and beyond. Because peak reproductive performance comes before the vagaries of a given individual's survival is determined, and the fact of that survival conveys no advantage to disseminating the genetic make-up, natural selection cannot select for advantages related to longevity. Moreover, in the larger context of species survival and biodiversity, the crowding of the human ecosphere with older persons would seem to have had more liabilities than assets over evolution. We cannot learn from nature how to feed and nourish the oldest old. The lessons, if any, would be cruelly averse to our humanitarian values. However, we do have values and they guide us to the goal for quality of life for the assorted conditions of the extremely old.

The choices are *laissez faire* or *laissez aller*. If we are ignorant about how to achieve the goals, perhaps the 'first do not harm' principle should be operative. Should we decide that prescription of diet and adjustment of nutritional stores are required, hypothesis-based research to provide evidence-based practices is required. We may be facing a true Heisenberg principle. The fact that ageing leads to the greatest heterogeneity among individuals complicates the generation of universal principles for prescriptive actions. Another quandary could be the fact that insufficient individuals within the age groups of interest are available for outcome research in any given area to provide statistically robust findings.

Shifting once again to the lowest extreme of human survival, we know that what is good for the full-term infant is not the formula for the 600 g premature neonate. Failing to heed the distinction can be lethal. My suspicion is that what is good dietary practice for the younger adult is also not what is best for octogenarians. I would predict that a new inter-generational confrontation is in the offing as we recognise and raise the issues of alimentation of the extremely old. It is the tyranny of the preventive regimens of assorted guidelines to be imposed across the whole population that may exacerbate the tension between young and old, although the young's consuming a more healthful diet will presumably allow more of them to eventually reach the status of

advanced age, and hopefully with greater health, vigour and function.

Conclusions

For 99.9% of human evolution, persons living to 80 years or more constituted an unprecedented anomaly and persons over 60 years of age were a rarity. Today, in all parts of the world, they constitute the most rapidly growing sector. Food nourishes their bodies and diet influences their health; better or poorer health and nutrition of the elderly impacts on economic costs for health care and social costs in intergenerational tension.

An analysis of the evidence for how best to guide and instruct persons surviving to these upper extremes of life reveals there is none. The heterogeneity of the population and its dispersion across societies may impede an effective address with the scientific method. Whatever be the level of empiricism or fatalism that ultimately governs recommendations for the diet that the oldest old should subsist on, the issues of the collective social values for extended quantity or heightened quality of life at any age must be confronted and addressed. That has been the purpose of this inquiry.

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