AGEING THROUGH THE AGES

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Throughout the millennia, mankind has pursued the concept of achieving eternal youth. An example of this is the classical pantheon of immortal gods. Again there are the nine Judaic patriarchs with life spans between 777 and 962 years. In the Middle Ages, a major interest of alchemists was to produce an 'elixir of life'. Interest in longevity has been revived in the twentieth century, starting with the transplantation of monkey glands, and moving to the relevance of genetic modification and the use of hormones and anti-oxidants. Those involved in this field might heed Swift (1667-1745) when he describes the Struldburgs, beings who are immortal but live the most miserable of lives, warning that if longevity is to be of benefit it should be linked to a high quality of life.

Progress towards the goal of healthy longevity has lagged well behind the aspirations of philosophers. This paper reviews the record of ageing by considering life span from earliest times to the present as revealed by historical records and archaeological findings. This inevitably will produce biased information, since until recently details have been recorded only on the rich or famous, and a variety of factors have led to the inhumation and preservation of only particular skeletons at particular sites.

There is also the problem of calculating the age from bones. This is relatively easy in childhood and adolescence where age can be assessed by a number of features such as the appearance and fusion of centres of ossification,[1] and by the eruption and development of teeth.[2] The assessment of adult bones is much less precise and a subject of debate especially in terms of reliability and racial variation. Analysis of the pubic symphyseal surfaces can be used to estimate the decade of age at death.[3] Changes to the costochondral junction can give similar estimates.[4,5] Tooth root sclerosis by deposition of hypermineralised, peritubular dentine leads to an increase in root transparency and this can also be used to estimate the age of the tooth.[6] Other techniques that were popular such as the closure of cranial sutures, variations in tooth wear, and arthritic and osteoporotic changes in long bones, are no longer considered as reliable ageing criteria.[7] All these techniques can be made more accurate by using them simultaneously and including them in a multifactorial equation,[8] and also by knowing the sex of the skeleton - a subject in itself that is not straightforward.[9] In general there is a feeling among anthropologists that skeletal age is often underestimated.[10]

An indirect assessment of dietary status can be achieved by measuring height, examining the pattern of dental wear using the $^{13}C/^{14}C$ ratio to assess the amount of vegetation in the diet, and analysing trace elements from a sample of bone to provide more detailed information on the content of the diet.[11] Porotic changes within the orbits (*cribra orbitale*) are considered to be evidence of iron deficiency, though recent studies indicate that recurrent infections may be as important a cause as poor nutrition.[12]

Given the complexity of archaeological patterns in different societies, this account is confined mainly to changes in the British Isles and Europe.

PALAEOLITHIC PERIOD

Neanderthals (200,000-30,000 BC), who were the losers in the struggle for survival over other hominid species, had the additional disadvantage of suffering from racial prejudice. Reconstructed drawings portray them as ugly, inarticulate, shambling idiots. These misconceptions relate to the examination of a skeleton between 1911 and 1913 from an individual with multiple pathology.[13] The features included cervical and dorsal osteoarthritis, an old rib fracture, osteoarthritis of both shoulders, multiple tooth loss, and dental abscesses. In this situation, it is not surprising that the individual had a stooped posture. Paradoxically, that he survived for so long with severe disablility is possible evidence of altruistic friends and relatives providing an early example of community care!

Excavation of Neanderthal skeletons has identified a number of childhood skeletons, and, in a group of adults, histomorphometry established the ages of death of four skeletons as 24, 36, 40 and 41 years.[14] Although the sample is small, that half of them reached the age of 40 years suggests that they fared at least as well as adults in many societies much later in prehistoric and historic times. Their life expectancy is even more remarkable given the high prevalence of healed skeletal injuries amongst their remains; an indication of the hazardous nature of their lifestyle, and their apparent willingness to help one another when in difficulty.[15]

Anatomically, modern humans (120,000 BC onwards) were latecomers to Europe from Africa around 50,000 years ago. In a sample of 72 skulls from a site in Spain pathological features include hyperostotic ear disease, three osteomas, a severe head injury, maxillary osteitis, a dental abscess, and *cribra orbitale*.[16] Assessment of the age at death in another group established that there were few infants and children, with many adolescents and young adults, but fewer individuals in middle age.[17] None had survived beyond 40 years. The lack of availability of infants and children for study may be due to their separate burial.

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MESOLITHIC (10,000-6000 BC)*
Relatively little is known about the life expectancy of individuals from the mesolithic period.

NEOLITHIC (6000-2000 BC)
The major development in the neolithic period was the change from a hunter/gatherer to a pastoral/agricultural society. It has been suggested that adopting a more settled lifestyle could have led to malnutrition,[18] but comparison of mesolithic and neolithic skeletons in Portugal showed no evidence of this.[19] Certainly, the world's human population increased rapidly in this period.[20] Analysis of 170 Neolithic skeletons from a rock shelter in France[21] indicated that the group had a life expectancy of between 25 and 28 years.

BRONZE AGE (2000-700 BC)
Review of human remains in an early Bronze Age Austrian necropolis indicated a life expectancy of only 24 years.[22] The ages estimated for seven skeletons from another site in Austria relating to the Late Bronze Age were 3, 6, 8, 9, 30, 40 and 45 years.[23] It is significant that two individuals were 40 years or over so that even though the mean life expectancy was low, a proportion of the population reached middle age.

Although many mummies were entombed in Egypt during the Bronze Age, selective burial and tomb robbing have made it difficult to obtain a valid sample to calculate life expectancy. Useful pathological information has been obtained from the study of individual mummies: parasitic infections were common, as were tuberculosis and sand pneumoconiosis.[24] Despite their aristocratic antecedents, 30% of mummies had radiological evidence of Harris lines suggesting recurrent bouts of poor health or malnutrition in childhood.

Arnott[25] paints a picture of poor health amongst the ordinary members of Minoan and Mycaenian society where water was contaminated, there was overcrowding, and the diet was seasonal and unbalanced. Skeletal analysis has revealed evidence of malaria, anaemia, poliomyelitis, and pyogenic infections. Other disorders not associated with skeletal change, such as cholera, typhoid and dysentery may have been equally common. Signs of nutritional deficiency included rickets and scurvy.

Poor health was probably associated with urbanisation so that a mean life expectancy of 35 years in the Minoan and Mycaenian areas at the beginning of the Bronze Age later fell to 31 years. Skeletal analysis of rulers revealed that they were taller and more heavily built than their subjects, and that they rarely showed signs of poor nutrition.

Details on the ages of the Kings of Judah between about 1000 and 600 BC recorded in the Old Testament are given in Table 1. Excluding several in whom either the date of birth or death was omitted, their mean life expectancy was 48 years ranging from 24 to 68. This further emphasises the importance of a high standard of living for a prolonged life expectancy.

*As social and cultural development varied throughout Europe, initially due to northward migration as the glaciers retreated, but later due to the slow spread of innovation and cultural change, the dates applied to each period are approximations.

TABLE 1
Ages of Kings of Judah recorded in the Old Testament.

Name of King	Age at death (yrs)
Rehoboam	58
Joram	40*
Joash	47*
Amaziah	54*
Uzziah	68
Jotham	41
Ahaz	36
Hezekiah	54
Manasseh	67
Amon	24*
Josiah	39*

*Killed

IRON AGE (700-0 BC)
There are a considerable number of cist burials in Scotland which have been used to define ages of death during this period. It is frustrating that many excavations were conducted in the nineteenth and early twentieth century when approaches to measuring skeletal age at death were less systematic and hence the ages assigned less reliable. In a recent excavation, a large cist contained the remains of a child aged 4, a young male adult, two females between 30 and 40 and one female aged 40 years.[26] More recently, excavation of 18 cists identified a child aged 10-11, one young female aged 18-21, one young male aged 25-35, two males and one female aged 35-45, and one old woman and a male and a female aged over 45 years.[27] Such figures suggest an improvement in life expectancy during the Iron Age although this is based on a very small sample size; sources of bias include the possible burial of infants elsewhere and selection of individuals buried in a cist.

CLASSICAL PERIOD (700 BC TO AD 400)
An early paper on mean life expectancies of Greeks and Romans stated that these were 35 and 32 years respectively.[28] Since such data relate to excavations performed before accurate methods of skeletal analysis were available, they are of dubious validity. Monatagu[28] took an alternative approach of identifying the ages of death for males in the Oxford Classical Dictionary, comparing them with entries in Chambers Biographical Dictionary from 1850-1899, 1900-1949 and 1950-90 (Table 2). Those who died violent deaths were excluded. The mean life expectancy of the ancients was almost identical to males dying between 1850 and 1959. It is only in the last 40 years that the mean male life expectancy has exceeded this. The constraints in accepting these data are that famous people had to live long enough to become famous and that they were likely to be better nourished than most of their contemporaries. It is clear, however, that even without the benefits of modern medicine individuals who could afford a healthy lifestyle often achieved longevity.

After 100 BC the mean life expectancy of Roman males fell from 72 to 66 years. It has been suggested that lead poisoning might be the cause, however absorption spectroscopy has established that the lead content of Roman bones was less than half that of modern Germans.[29]

TABLE 2
Median length of life for individuals born before 100 BC compared with those who died: AD 1950-1990; AD 1900-1949; and AD 1850-1899.[28]

Population	Median life span (yrs)	Range of life span (yrs)	p
Born <100 BC	72	32-102	
Died AD 1950-1990	78	46-101	p <0.001
Died AD 1900-1949	71.5	29-105	N.S.
Died AD 1850-1899	71	19-95	N.S.

EARLY MIDDLE AGES (AD 400-1000)

The excavation of two Anglo-Saxon cemeteries in England established that in 65 burials the mean age at death was 36 years, with 48% of the skeletons under the age of 10 years and none over the age of 45.[30] When reports on 12 Anglo-Saxon cemeteries in central and central southern England were reviewed they indicated that, out of 687 skeletons with identifiable ages, 1% were of neonates, 6% infants, 12% juveniles, 13% subadults, 52% adults, and 16% elderly.[31] The precision of the ageing of adult skeletons is questionable in some sites since the dates of excavations ranged from 1853 to 1981.

A particularly interesting excavation was that of a Pictish cemetery[32] which contained one infant (16-20 months), one child (8 years), six young adults (15-25 years), five middle-aged adults (35 to 45 years), and two elderly adults. This gives a mean life expectancy similar to that of the Anglo-Saxons. The same caveats on skeletal ageing using data more than 50 years old apply.

LATE MIDDLE AGES (AD 1000-1600)

The mean life expectancies of the Kings of Scotland and England were 51 and 48 years respectively (Table 3). Though nine Scottish and seven English sovereigns died in battle, from accidents, from assassination or from execution, their more comfortable accommodation and better nutrition meant that they usually lived longer than the lower orders. The distinction between such individuals and the general population is illustrated by the excavation of a fourteenth to fifteenth century graveyard in Stockholm where the ages of death were estimated as between 20 and 39 years for 102 skeletons, and for another 241 as between 40 and 59 years, giving a mean life span of only 36 years.[33]

A study of a Franciscan cemetary in England of burials from the thirteenth to sixteenth century gave an age range for friars and lay people, children and adults and males and females. With a mean age of death of approximately 39 years[34] this relatively high life expectancy may have related to the healthy life style of monks and the possibility that only wealthier members of the community were buried in the site.

Similar studies have been conducted on burials in Carmelite Friaries in Aberdeen and Linlithgow between the thirteenth and sixteenth centuries.[35] In Aberdeen the median age of death of 105 subjects was 24 years, with 34% being dead before the age of 12 years, and only 5% surviving into 'old age' (over 45 years). The mean age of death could not be calculated because individuals over the age of 25 years had been merely categorised as being young, middle-aged or old. In Linlithgow, with the exception of 18 fetal or perinatal deaths, the median age of death for the group was 16 years with 42% dying before the age of 12 years and only 4% surviving into 'old age'.

'THE FOUR HORSEMEN'

There is no doubt that throughout prehistory and history up to the present, warfare, famine and plague have combined as major causes of death. In most instances warfare has increased mortality in the general population because of the associated plague and famine rather than directly through battle. It is estimated, for example, that from 1348 to 1349, plague destroyed between a third and a half of the population of England.[36] More accurate information is available from Florence in the fifteenth and sixteenth centuries when mortality was detailed as part of the record of a Dowry Fund administered for 19,000 girls and women.[37] These data establish that the outbreaks of plague in 1430, 1437-38, 1449-50 and 1527-31 produced a five-to-tenfold increase in the mortality of this group.

One of the few accurate pieces of information on the effects of nutrition on mortality is provided by a review of the parish registers from Eden Valley, Cumbria between 1557 and 1812. There was a clear link between an increase in wheat price indices and infant mortality.[38] This is evidence that even in comparatively recent times a large section of the population suffered from a subsistence economy.

TABLE 3
Age at death of Scottish and English sovereigns born after AD 1000 and dying before AD 1600 (Data on late Saxon kings omitted because of doubt concerning date of birth).

Nationality of sovereigns	Age at death (yrs)						
	10-19	20-29	30-39	40-49	50-59	60-69	70-75
Scottish	0	1	5	6	3	5	2
English	1	0	3	7	6	4	0

TABLE 4
Age distribution determined by skeletal analysis of adolescents and adults at Christchurch, Spitalfields.[39]

Age (yrs)	15-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-95
Number	2	14	23	23	48	52	38	17	2

SEVENTEENTH TO NINETEENTH CENTURIES

One of the most comprehensive reviews of the health and date of death of individuals in the eighteenth and nineteenth centuries has been obtained by the examination of bodies interred in the crypt of Christchurch, Spitalfields during the eighteenth and first half of the nineteenth century.[39] Many had a Hugenot background, their socio-economic groups being artisans (48%), master craftsmen (32%), and the remainder, professionals, merchants, wholesalers, or of private means. Analysis of the skeletal remains of adolescents and adults suggested a mean age of death of 58 years (Table 4). Another approach is to calculate the age of death from plaques on coffins. This survey which included infants and children gave a lower mean age of death of 46 years (Table 5). Even the lower figure indicates a substantial improvement in life expectancy since the late Middle Ages.

Another window to the eighteenth century is a census of the Scottish population collected by ministers of religion and recorded by Webster in 1755.[40] The proportion of Scots over 65 years was 5.1%, over 75 years was 1.5%, and over 85 years was 0.3%. Even in these challenging times, 29 individuals between the ages of 95 and 100 years had almost reached the maximum life expectancy for humans.

NINETEENTH CENTURY TO THE PRESENT

The introduction of an annual report from the Registrar General in Scotland in 1855 has provided much more accurate information regarding ageing. For example, the mean life expectancies of men and women between 1861 and 1870 of 40.3 and 43.9 years had almost doubled by 1995 to 72.1 and 77.6 years respectively (Table 6).[41]

Important reasons for this include an improvement in nutrition, better housing and public health measures such as the prevention of major epidemics.

THE FUTURE

Measures which might increase further the mean life expectancy are preventative ones such as avoiding smoking, cutting back on excess alcohol, maintaining an ideal body weight, taking regular exercise and eating adequate amounts of fresh fruit and vegetables. The identification and treatment of hypertension, diabetes mellitus and cancers of the cervix, breast and colon are also of proven benefit in old age. In monitoring the effectiveness of such measures it is important to not only look at life expectancy but also at active life expectancy.

Genetic manipulation might also increase lifespan. Genetic modification can extend the lives of yeasts and nematodes,[42] but whether this would be desirable in a human population remains to be seen. Diet might also be important. Thus in rodents, a 40% restriction in calorie intake early in life achieves a 50% increase in life span.[43] There is also evidence that antioxidants such as vitamins A or E reduce the degree of lymphocyte DNA mutation associated with ageing.[44] Many drugs have been used in an attempt to arrest or reverse ageing but scientists have not yet found the elixir of life.

TABLE 5
Age at death determined by reading coffin plaques of individuals interred at Christchurch, Spitalfields.[39]

Age (yrs)	0-1	1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-
Number	37	40	14	19	33	35	62	65	61	20	3

TABLE 6
Mean life expectancies between 1861 and 1995 for males and females from birth and from 65 years.[41]

	Life expectancy from birth (yrs)		**Life expectancy from 65 (yrs)**	
Date	**Males**	**Females**	**Males**	**Females**
1861-1870	40.3	43.9	10.8	11.6
1891-1900	44.7	47.4	10.8	11.9
1930-1932	56.0	59.6	11.0	12.6
1960-1962	62.2	72.0	11.5	14.2
1995	72.1	77.6	13.8	17.1

CONCLUSION

From the palaeolithic to the late mediaeval period the mean life expectancy of humans increased from between 20 and 30 years to 30 to 40 years. Exceptions are that kings, aristocrats and other wealthy individuals lived almost as long as the current political, professional, and commercial leaders. Between the seventeenth century and the late eighteenth and early nineteenth century the mean life expectancy increased to between 40 and 50 years. Thereafter, it has increased rapidly to between 55 and 60 in the 1950s, 60 to 70 in the 1960s, and 70 to 80 years in 1995. There seems little doubt that a general improvement in the health of individuals will further increase the mean life expectancy in most countries. If there is a breakthrough in the extension of maximum life span, the questions may be whether anyone would want to live to be 200 years old, and whether we should concentrate on prolonging the lives of the few in a world where many people continue to suffer from poverty, hunger, plague and warfare.

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