Less Brain, Less Brawn: A New Evolutionary View of Man

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One familiar and common depiction of man's evolution can be found in abundance and in a variety of places from textbooks to popular media. This is an illustration portraying the profiles of a group of hominids moving along in line through the trail of evolutionary time. The trail begins with a short individual carrying a drooping stature and a small head, and progresses through individuals becoming increasingly taller, straighter and bigger-headed. The last of them, the tallest, straightest, and the one with the biggest head, is the modern man, *Homo sapiens*. This popular view has now been shaken by a recent study. The study shows that sizes of both body and brain, have been on a steady decline over the last 50,000 years after bursts of steep increase in the half million years preceding the decline.

The new study appearing in the 8th May 1997 issue of *Nature* (by Ruff C B, Trinkaus E and Holliday T W, Volume 387. pp. 173–176) is a highly comprehensive one and has used 163 fossils of members of the genus *Homo*, who lived during the last two million years. Using a new and robust method, the study estimates that living humans are smaller by about 9% to 13% than ancestors who lived anytime in the Pleistocene (1.95 million to 100,000 years ago). Further, there appears to be steady decline over the last 50,000 years. The study also shows that brain-sizes of early modern humans, who lived between 90,000 and 30,000 years ago, were about 10% larger than that of living humans. Like body-size, brain-size has continued to decrease till today.

Reliability in Body-Mass Estimation

Though body-mass is an important measure against which many morphological variables have been correlated, its accurate estimation from skeletal specimens has been quite problematic. A common approach is to measure the head-to-toe or pelvis-to-toe length as these are well correlated to body-mass. But because a substantial number of specimens are fragmentary, palaeoanthropologists find it impossible to get large and reliable representations of these measurements for different geological periods. Various other indices used to estimate body-mass have relied on parameters like thickness of skull and tooth, or size of the eye-socket. Most of these, however, have proved to be unsatisfactory as estimated body-masses have varied by as much as 50%. Therefore, the lack of reliable estimators of body-mass of ancestral hominids has posed a major challenge to palaeoanthropological studies, specially those that have attempted to examine trends across evolutionary time.

After about two decades of search, Christopher Ruff, the lead author of the paper describing the study, seems to have hit upon

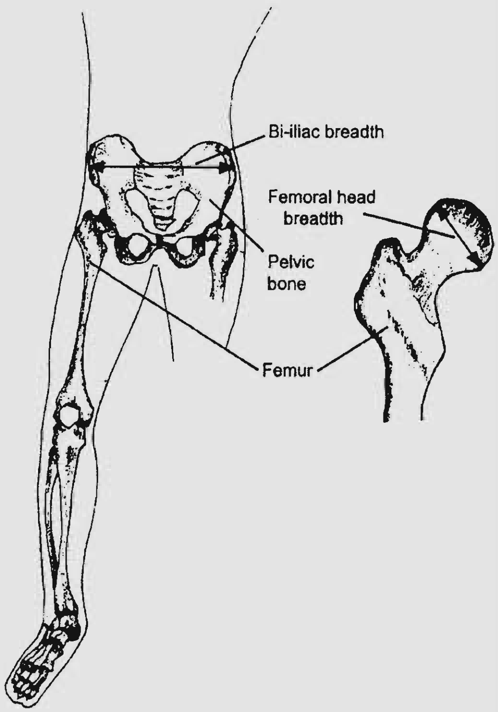

Figure 1. (illustration of femur-head – breadth and bi-iliac distance). The width of the femur-head and bi-iliac breadth were two variables used to calculate body mass. The head of the femur is that part of the thighbone that goes into the socket of the pelvis, and bi-iliac breadth refers to the maximum breadth of the pelvic bones.

a robust method that might serve as a reliable indicator of body mass. It is known from medical and forensic studies that accurate morphological indices of body-mass must consist of features that have a functional relation to body-size. The challenge was to find features that are both appropriate as well as adequately represented in fossil records. In this study, two independent features to estimate body-mass were compared and the concordance in the results showed that these were reliable to work with. The first of these was the breadth of the head of the femur (the breadth of the 'ball' of the thighbone that goes into the 'socket' of the pelvis; *Figure 1*). Body-mass in living humans is proportional to the breadth of the femoral head (the heavier the body, the larger the femoral head to support its weight). Apart from being a good index, it is easy to make reliable measurements and a large sample of femoral specimens is available. The second feature was based on the relationship of stature (height) and bi-iliac breadth (maximum breadth of the pelvis) to body-mass. Both these methods were applied to the specimens and it was found that the resulting pairs of estimates of body-mass were almost exactly similar. This instilled confidence in using these indices to obtain robust estimates of body-mass of human ancestors from skeletal samples.

Body-Mass Decline over Recent Time

Once the breakthrough in estimating body-mass was achieved, the next step was to look at trends across evolutionary time. The results clearly indicated that present-day humans were not only smaller than their ancestors but were also gradually becoming even smaller. The peak in body-mass was achieved by archaic *Homo sapiens*, popularly called *Neanderthals*, who lived between 75,000 and 36,000 years ago – they were an amazing 30% larger than living humans today (*Figure 2*).

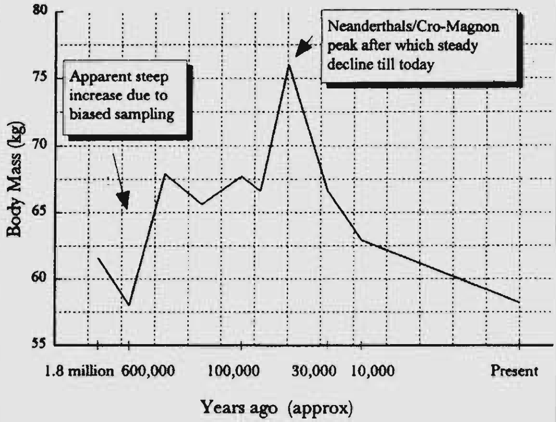

Figure 2. The trends in body-mass over the last 2 million years. Time on x-axis is scaled to log_{10}.

That the *Neanderthals* were huge was never in doubt, but what is intriguing is that it now seems other gigantic hominids were walking the earth as early as two million years ago. The average body-mass of specimens from the Pleistocene (1.95 million to 100,000 years ago) was a significant 12.7% larger than the living humans. Further, more than 75% of the 163 specimens dated between 1.95 million and as recent as 10,000 years ago, had higher body-mass than living humans.

Further surprise was in store when the authors discovered a steady decline in body-mass between 50,000 and 10,000 years ago. This period happened to coincide with the appearance of 'anatomically modern humans', a group from which modern man is believed to have descended. The decreasing trend appears to be have continued till today as pointed out by a comparison of specimens from this period and living humans. The body-mass of the specimens were significantly higher by 11–12% than living humans. However, this significant difference was present only for lower-latitude comparisons. The difference in body-mass of high-latitude specimens and present-day humans from high latitudes (>30 N) was small (0.3–3.7%) and not significant.

The authors caution that while interpreting the difference of 12.7% between Pleistocene specimens and living humans, the magnitude of difference between Pleistocene ancestors and present-day humans may be exaggerated because of interference from factors like latitude at which the specimen lived and its sex. Even among present-day humans, those living at higher latitudes are larger than those at lower latitudes, and males are larger than females on an average. To correct any bias that might have crept into the analysis because of unequal samples from different latitudes and sexes, an analysis filtering out these effects was carried out. This showed that these Pleistocene ancestors would have been at least 9.2% larger than living humans. The larger body-mass difference of 12.7% was an artifact of both, including more samples of both males and high-latitude areas.

The Rise and Fall of Brain-Size

Once body-mass was established, brain-sizes were estimated using well-known relationships that already exist. Though there were 6-footers walking around about two million

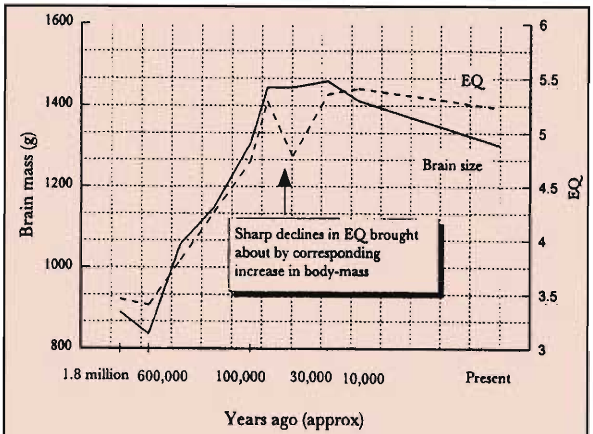

Figure 3. The trends in brain-mass and Encephalization Quotient (EQ) over the last 2 million years. The continuous line is brain-mass with units on the left y-axis, and the broken line is EQ with units on the right y-axis. Time on x-axis is scaled to log_{10}.

years ago, the sizes of their brains were only about a third of the humans (*Figure 3*). This small-sized brain prevailed for more than a full million years and was followed by a most remarkable spurt of increase that occurred in the next half-million years (between 600,000 and 100,000 years ago). Peak brain-sizes greater than 10% of the present-day humans were found in samples from Israel belonging to cave-dwelling people such as those who lived in Skhul and Qafzeh around 90,000 years ago, and from the Cro-Magnon cave painters of France who lived about 30,000 years ago. Like body-mass, absolute brain-sizes have also steadily declined from the times of the Cro-Magnon people to today.

Big isn't always the best and what really matters is the size of the brain relative to size of the body. An index called the Encephalization Quotient (EQ), which is a ratio of brain-mass to body-mass, has often been equated to intelligence. Because brain-size and body-mass varied through time, the trends in EQ over time do not necessarily correspond to trends in either body-mass or brain-size. EQ values between 1.95 million and 600,000 years ago, were only a third of the current value, and did not exhibit significant changes during this period (*Figure 3*). EQ values rose dramatically after 600,000 years ago and quickly reached about 90% of the current value as early as 100,000 years ago. However, there was a sharp drop in EQ between 100,000 and 30,000 years ago corresponding to massive increases in body-size during this period. Body-size became smaller thereafter, resulting in another increase in EQ to levels comparable to today's. Though there seems to be a small decline since then, the changes are not significant.

Plausible Selective Forces for the Changes

What factors might have influenced large changes in body-sizes after more than a million years (1.95 million to 600,000 years ago) of relative stability? Various reasons have been put forward but they are still speculative. What is interesting is that body-size during this period was much larger than that of living humans but it was not accompanied by large brains and therefore high EQ values. After 600,000 years ago, brain-sizes might have increased to keep up with the massive increases in body-size. But then, what could have caused an increase in body-size?

A common explanation has been that movement to higher latitudes may have been accompanied by increases in body-size because resultant lower surface-to-volume ratio might have helped combat cold conditions. But as John Kappelman points out (*Nature*, Volume 387. pp. 126–127, 1997), there exist some low-latitude specimens which are quite large. Kappelman suggests that large body-mass, at least among males, might have arisen because of consequences of competition for females, as is found with our ape-relatives. At later stages, the need for large bodies might have become less important with the emergence of factors like cooperative hunting and better communication skills. Even later declines in size might have occurred because of relatively poor nutrition as agriculture replaced the more varied diet of the hunter-gatherer. The movement toward use of tools and domestication of animals could have also contributed to decrease in body-sizes resulting from relatively less physically active modes of lifestyles.

An important implication is that our intelligence might have evolved more because of selection acting on body-sizes rather than brain-sizes as was previously thought. The commonly held notion of man getting bigger and wiser, now seems a tall story. Man got smarter because he got smaller.

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INTEL'S NEXT GENERATION OF CHIPS

Intel has designed a new generation of memory chips capable of storing not one but two bits of information on each transistor, effectively doubling the storage capacity of a chip. In addition, Intel engineers think that in the future they may be able to build chips holding four or more bits on each transistor. The new chips will use "multilevel cell flash memory," which is able to go beyond binary (zero-or-one) readings and sense four distinct states – equivalent to two bits of data.

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