

Body Mass Estimates and Encephalization Quotients: A Fresh Look at the Australopithecines and *Homo habilis*

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Abstract

The australopithecines and *Homo habilis* have been publicized for years as examples of evolutionary transitional forms that launched our own human lineage. Dogmatic evolutionists have rationalized these claims on the basis of brain expansion, encephalization quotients, and bipedalism. However, any evolutionary justification for brain expansion in these extinct creatures must rest in a precise model for the determination of body mass. To insure an accurate body mass model, one must take into account whether the animal is quadruped, facultative biped, or obligatory biped. Past body mass estimates for the australopithecines and *Homo habilis* were based on assumptions about their bipedalism that have proven to be erroneous. When a body mass model is used accounting for the facultative bipedalism of the australopithecines and *Homo habilis*, the data shows that they are not highly encephalized, and hence nothing more than a microevolutionary adaptation of the pan-troglodytes.

Introduction

One of the classic examples of alleged evidence for human origins that evolutionists have proposed to promulgate the evolutionary transitional status of the australopithecines and *Homo habilis* is a comparison of increasing cranial capacity versus their perceived evolutionary timescale (Falk, 1980; 1987; 1998; Kirkwood, 1997; Lee and Wolpoff, 2003; McHenry, 1994a). In this context, various fossilized crania are plotted against time as an attempt to demonstrate a gradual increase in brain volume from the time of our perceived most recent common ancestor to the large-brained humans we observe today (Figure 1). The goal of this type of demonstration is to provide visual evidence (however

weak) that some evolutionary advancement in intelligence over time has occurred.

Realistically, the scientific validity of using cranial capacity alone as a justification for brain expansion through any perceived evolutionary timescale is suspect at best, because there is no correction for body size (McHenry and Coffing, 2000; Kappelman, 1996; Holloway, 1988; Conroy et al., 1990). It is also in significant dispute as to whether the relative brain size of the australopithecines actually did increase over perceived evolutionary time (Falk, 1987; 1998; Martin, 1990). However, the majority view in evolutionary thinking appears to indicate that the australopithecines did possess a larger relative brain size than the apes (Pilbeam and Gould, 1974). Moreover, assuming it is a valid taxon (Brace, 1979; Wood and Collard, 1999), *Homo habilis* is believed to be the first creature to demonstrate a measurable increase in relative brain size (Falk, 1987; Lovejoy, 1981; Hawks et al., 2000; Pilbeam and Gould, 1974; Haeusler and McHenry, 2004; Ruff et al., 1997).

While a larger brain is not necessarily a predictor of higher intelligence (Beals et al., 1984; McLeod, 1983),

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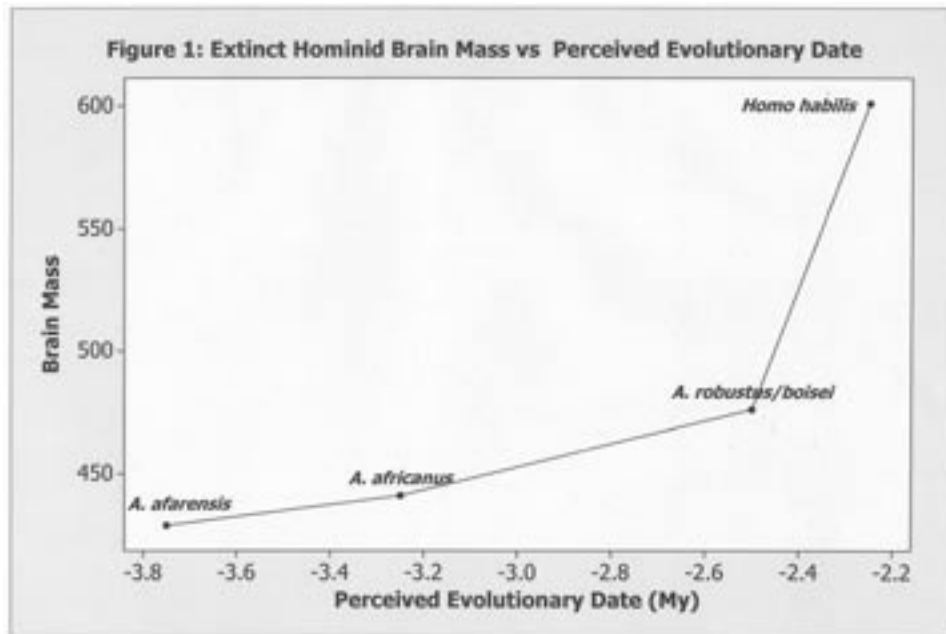


Figure 1. Extinct hominid brain mass versus perceived evolutionary date.

brain size is known to have a strong positive correlation with body size (Jerison, 1970). In other words, a larger body size usually requires more neurons and thus a correspondingly larger brain to handle the increase in total structural mass. However, neither suggests any true evolutionary adaptation (Pilbeam and Gould, 1974; Jerison, 1976), nor evolution to a higher taxonomic group (Cheek, 1981; Custance, 1968; Hummer, 1977; 1978; Cuzzo, 1977). Also, Jerison (1976) noted:

...large brains do not, in general, confer an evolutionary advantage over smaller brains. Instead large and small brains represent different but equally good evolutionary outcomes (p. 90).

Currently, plots using cranial capacity alone as perceived evidence for some evolutionary advancement have fallen out of favor (Duffett, 1983). Instead, evolutionists seem to have converged on the concept of encephalization which was originally proposed by Dubois (1897). The Dubois allometric factor is based on an impromptu association of brain size to body size/body function which results in a somewhat predictable logarithmic relationship (Jerison, 1970). Dubois' initial work on encephalization has been significantly refined over the years with the extensive experimental research on primate brain size by Jerison (1970) and Martin (1990). The result of their work was the proposal of an encephalization quotient which is defined as the ratio of the true mass of a brain to the anticipated mass of the brain for a given body size (Jerison, 1970; Martin, 1990). It is essentially nothing more than an index of brain volume

that can be compared to different organisms. However, the relationship fails to scale properly across different taxonomic groups of mammals (Pagel and Harvey, 1989). The allometric relationship is traditionally derived from a bivariate regression analysis of brain volume and body weight to determine the degree of encephalization of the animal in question (Sacher, 1970; Martin, 1990). Since a majority of mammals are expected to have an encephalization quotient of 1, a higher encephalization quotient implies the organism is more complex (Jerison, 1970; Martin, 1990; McHenry, 1988).

The australopithecines are an extinct group of creatures

alleged to be an early evolutionary branch of divergence from chimpanzees (Ayala and Cela-Conde, 2003). Some believe they are transitional forms that are forerunners to the genus *Homo* (Wood and Collard, 1999; Wood, 1992; Tobias, 1991; Skelton and McHenry, 1992). Others believe they are nothing more than an extinct evolutionary branch (Pilbeam and Gould, 1974), and others believe they are simply an extinct form of ape (Cuzzo, 1977; Custance, 1968; Hummer, 1977; Lubenow, 1992; McLeod, 1983; Oxnard, 1975; 1984). More importantly however, Pilbeam and Gould (1974) have stated that at least three principal species of *Australopithecus* are all just different adaptations of the same animal and their brains are all equally expanded beyond the ape grade. In this context, evolutionists have elevated the australopithecines to a pseudo-transitional status higher than the pan-troglodytes for no other reason than a larger uncorrected average brain mass.

Louis Leakey et al. (1964) were the first to propose *Homo habilis* as the earliest member of the genus that evolutionists also place modern humans. *Homo habilis* is primarily distinguished from the australopithecines by its larger brain size (Haeusler and McHenry, 2004; Pilbeam and Gould, 1974; Susman, 1994; Blumenschine et al., 2003). *Homo habilis* has been proposed by evolutionists as the earliest hominid to exhibit the increased brain size required to evolve human intelligence. However, the validity of placing this extinct animal in the genus *Homo* has been in significant dispute ever since Leakey's discovery was first published (Wood and Collard, 1999; Kramer et al., 1995; Lieberman et al.,

1988; Miller, 2000; Tobias, 2003; Hummer, 1977; Hummer, 1978; Cheek, 1981; Custance, 1968).

The primary goal of the present study is to review different body mass models and determine which is a more accurate predictor of the physical size of *Australopithecus afarensis*, *Australopithecus africanus*, *Australopithecus robustus*, *Australopithecus boisei*, and *Homo habilis*. Encephalization quotients are then recalculated using the accepted body mass model to determine if the evolutionary transitional status for the australopithecines and *Homo habilis* has any scientific validity. Additionally, this paper will evaluate the accuracy of awarding transitional status to the australopithecines over pan-troglodytes.

Methods of Estimating Brain Mass and Encephalization Quotient

Brain Mass

The brain mass calculation below is taken from the formula used by Ruff et al. (1997). The equation was first derived by Martin (1981) employing a least squares regression analysis to determine a bivariate relationship of brain mass and cranial capacity using the data from 27 primate species. Ruff's regression equation (below) has a correlation coefficient of 0.995. The brain masses derived in this paper originate from the individual crania of each hominid fossil presented in Table I.

$$\text{Brain mass} = 1.147 \times \text{cranial capacity}^{0.976} \quad (1)$$

Encephalization Quotient

The encephalization quotient in the form presented below is taken from Ruff et al. (1997). This equation relates brain mass and body weight, and is derived from a regression analysis of 309 extant placental mammal species with a correlation coefficient of 0.96 (Martin, 1981; Ruff et al., 1997; McHenry and Coffing, 2000).

$$\text{EQ} = \text{brain mass} / (11.22 \times \text{body mass}^{0.76}) \quad (2)$$

Discussion

Determination of Hominid Body Weight

While there have been several papers published attempting to relate various cranial and post-cranial fossils to hominid body weight (Aiello and Wood, 1994; Jungers, 1988; McHenry, 1988; Wolpoff, 1973; Kappelman, 1996), estimations that employ hind-limb joint diameter seems to be the best predictor of total body mass (McHenry, 1992; Jungers, 1988; Ruff and Walker, 1991; Kappelman, 1996). Several

proposed regression calculations yield formulae extracted from either human data (McHenry, 1992) or from data that includes all hominoidea (Jungers, 1988; McHenry, 1992; Kappelman, 1996). The body mass formulae evaluated in this paper are based on two models proposed by McHenry (1992) utilizing human data (male and female North Americans, Khoisan, and Pygmy) and hominoid data (extant male and female apes along with the human data). Regressions using the human data assume that the animal in question is an obligatory biped, while regressions based on hominoid data include obligatory bipeds and animals that are facultative biped and quadruped.

Table II is a comparison of several hominid body weight estimates using McHenry's human and hominoid regression formulae. Generally, body mass calculations originating from the human regression formula will bias the data towards lower body weights because obligatory biped animals possess less muscle density in their upper body. Conversely, facultative bipeds or quadrupeds possess a much higher percentage of upper body mass because their primary mode of locomotion involves the use of their upper body extremities.

While some evolutionists continue to question using human data to calculate the body weight of extinct hominids (Jungers, 1988), countless articles have appeared in secular journals presenting data on encephalization quotients focused on calculated extinct hominid body masses originating from formulae based on human models (Aiello and Dean, 2002; Ruff et al., 1997; McHenry and Coffing, 2000; McHenry, 1994a; 1994b; Wolpoff, 1973). When McHenry first proposed his human model, it was not without some skepticism. McHenry (1992) stated, "It is difficult to assess whether human or hominoid formulae give the best results" (p. 421). Jungers (1988) said that "*Homo sapiens* should be omitted from these models because they possess abnormally large hind-limb joints for their body size and this condition does not characterize early hominids" (p.117). It has also been demonstrated that body weight estimations for *A. robustus* and *A. boisei* based on formulae derived from hominoid post-cranial remains correlate much better with their robust jaws than estimations based on human formulae (McHenry, 1991a).

McHenry (1992) has further stated: "Common sense might favor the human equations simply because all known hominids are bipedal" (p. 421). However, generally stating that all known hominids are bipedal is extremely misleading. The australopithecines (*A. afarensis*, *A. africanus*, *A. robustus* / *boisei*) and *Homo habilis* are all facultative bipedal (Wood and Collard, 1999) which is a very different declaration than just saying they are bipedal. A facultative bipedal animal is one whose primary mode of locomotion

Table I. Hominid Encephalization Quotient Data Using the Hominoid Body Mass Model

SAMPLE	CRANIAL CAPACITY cm ³	BRAIN MASS++ Grams	BODY MASS+		ENCEPHALIZATION QUOTIENT+++	
			Male (Kg)	Female (Kg)	Male	Female
<i>Australopithecus afarensis</i> ++++						
AL - 333-45	500	494	60	36	1.96	2.91
AL-162-28	400	397	60	36	1.57	2.34
AL-333-105	400	397	60	36	1.57	2.34
<i>Australopithecus africanus</i> ++++						
MLD 1	500	494	53	37	2.16	2.84
MLD 37/38	435	431	53	37	1.88	2.48
STS 5	485	479	53	37	2.09	3.76
STS 19/58	436	432	53	37	1.89	2.49
STS 60	428	424	53	37	1.85	2.44
STS 71	428	424	53	37	1.85	2.44
Taung	405	402	53	37	1.76	2.31
<i>Australopithecus robustus/boisei</i> ++++						
L388Y-6	448	444	76	40	1.47	2.38
SK 1585	530	523	76	40	1.73	2.81
KMN-ER 406	510	504	76	40	1.67	2.71
KMN-ER 732	500	494	76	40	1.64	2.65
OH 5	530	523	76	40	1.73	2.81
KMN-WT 17000	410	407	76	40	1.35	2.18
KMN-WT 17400	400	397	76	40	1.32	2.13
KMN-ER 13750	475	470	76	40	1.56	2.52
KMN-ER 407	506	500	76	40	1.66	2.68
KMN-ER 732	500	494	76	40	1.64	2.65
<i>Homo habilis</i> +++++						
KMN-ER 1813	510	504	75	41	1.69	2.65
OH 7	687	674	75	41	2.26	3.54
OH 13	650	638	75	41	2.14	3.35
OH 24	590	581	75	41	1.94	3.05
KMN-ER 3732	625	614	75	41	2.06	3.22
KMN-ER 1805	582	573	75	41	1.92	3.01
OH 16	638	627	75	41	2.10	3.29
<i>Pan-Trogodytes</i> +++++						
	410	380	49	41	1.88	2.00

+ Body masses are using the hominoid model and are obtained from McHenry (1992).

++ Brain Masses are obtained from the equation $BM=1.147 \times \text{cranial capacity}^{0.976}$

+++ Encephalization quotients are obtained from $EQ=BM / (11.22 \times \text{body mass}^{0.76})$

++++ Cranial capacities except for *Homo habilis* are obtained from Aiello and Dean (2002).

+++++ *Homo habilis* cranial capacities are obtained from Holloway (2000).

++++++ Cranial capacity and body weights are taken from extant data reported by Pilbeam and Gould (1974).

Table II. Hominid Body Mass Comparisons Using the Human and Hominoid Formulae

SAMPLE	BODY MASS		BODY MASS		PERCENT INCREASE+	
	Human Formula Male (Kg)	Female (Kg)	Hominoid Formula Male (Kg)	Female (Kg)	Male (%)	Female (%)
<i>Australopithecus afarensis</i>	45	29	60	36	33	24
<i>Australopithecus africanus</i>	40	30	53	37	33	23
<i>Australopithecus robustus/boisei</i>	49	32	76	40	55	25
<i>Homo habilis</i>	52	32	75	41	44	28

Body weights are taken from McHenry (1992).

+ Percent increase in body weight by using the Hominoid formula over the Human formula.

is brachiation. Wood and Collard (1999) concluded that the *Australopithecus* displayed a mixed locomotor strategy of terrestrial bipedalism with an ability to climb proficiently. Conversely, the participants in the genus *Homo* (except for *Homo habilis*) are characterized by a commitment to modern humanlike terrestrial bipedalism (obligatory bipeds) and a very limited ability for brachiation. *Homo habilis* also had long arms along with interpretations about hand bones strongly suggesting an animal well adapted for apelike tree climbing (McHenry and Berger, 1998; Wheeler, 1992; Suman and Creel, 1979; Marzke, 1997; Mehlert, 2000).

While Wood and Collard (1999) generally concluded that the australopithecines and *Homo habilis* possessed a secondary locomotor strategy of terrestrial bipedalism, others have reported that this terrestrial bipedalism was primarily a postural component that aided feeding (Hunt, 1994; Lovejoy and Heiple, 1970; Straus, 1962). Spoor et al. (1994) stated:

These observations support studies of the postcranial fossil record which have concluded that *H. (Homo) erectus* was an obligatory biped, whereas *A. africanus* showed a locomotor repertoire comprising facultative bipedalism as well as arboreal climbing [sic]. The labyrinthine evidence is consistent with proposals that bipedalism in australopithecines was characterized by a *substantial postural component*, and by the absence of more complex movements such as running and jumping (p.648, emphasis added).

Spoor et al. (1994) further admitted in the same article that their analysis of *Homo habilis*, while speculative, suggested that they relied less on bipedal behavior than the australopithecines.

Although Spoor, Hunt, Lovejoy, et al. believe that macroevolution is fact, they are admitting that the facultative bipedalism attributed to the australopithecines and *Homo habilis* is dominated by a postural component which is

primarily used for feeding (similar to the extant great apes) and is completely inconsistent with the more complex human obligatory bipedal movements.

The terrestrial bipedalism exhibited by the australopithecines and *Homo habilis*, even though demonstrated to be nothing more than a postural component, still appears to be the predominant evolutionary criteria for their perceived transitional status and thus links them (however weakly) to humans. However, some evolutionists have argued that the locomotion strategy of the australopithecines actually differed much more from humans than from the African apes (Oxnard, 1984; Verhaegen, 1990; 1993; 1994). Some have stated that the australopithecines could have even possessed exclusive locomotor adaptations characteristic of an environment that no longer exists (Du Brul, 1977; Oxnard, 1984; Puech, 1992; Verhaegen, 1992; 1993).

Extant brachiating animals possess much greater mass in their upper body than obligatory bipeds because their upper body muscles are used more for locomotion purposes. Since the australopithecines and *Homo habilis* are known to be facultative bipeds, a model to calculate their body mass utilizing data only extracted from extant obligatory bipeds (humans) would result in an inaccurate number. A model recognizing the greater upper body mass of brachiating animals, with which the australopithecines are more closely associated, should produce a body weight number that is much more accurate. As an example, calculations using the McHenry hominoid model over his human model results in an average body mass percent increase of ~41% for males and ~25% for females. This data is shown in Table II.

Encephalization Quotients of the Hominids

Table I presents the measured cranial capacities, calculated brain masses and corresponding encephalization quotients

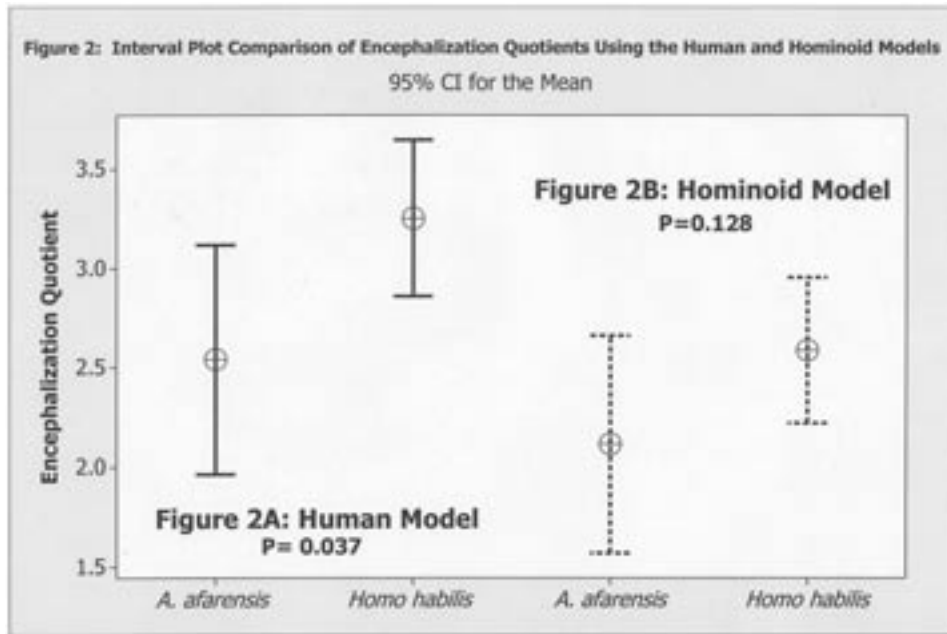


Figure 2. Interval plot comparison of encephalization quotients using the human and hominoid models

for several hominid species, including *Homo habilis*. This paper will abide by the convention of Aiello and Dean (2002) and combine the endocranial volumes of *A. robustus* and *A. boisei* into one species for analysis purposes. Endocranial volumes for the hominids in question are taken from the Encyclopedia of Human Evolution and Prehistory (Holloway, 2000).

Some evolutionists have proposed that the fossil cranium KNM ER 1470 should be identified as *Homo habilis* (Blumenshine et al., 2003; Tobias, 1987; Aiello and Dean, 2002; Holloway, 1988). However, this claim continues to be in dispute (Walker and Shipman, 1996; Holloway, 2000; Lubenow, 1992; Ayala and Cela-Conde, 2003; McHenry and Coffing, 2000). So the cranial data of KNM ER 1470 will not be included as *Homo habilis* in this study.

Encephalization quotient calculations typically use data that are a statistical average of brain mass and body mass (Holloway, 1988, 2000; Aiello and Dean, 2002). However, the sexes of very few crania (if any) are actually known (McHenry, 1991b). This is principally because the discovery of intact crania with associated post-cranial fossils is very rare, resulting in sample sizes too limited to obtain a statistically valid average. Furthermore, White (1998) has previously stated that the coefficients of variation for endocranial capacities in modern great ape and human samples can range between 8% and 15%. Since there is no reason to believe that the coefficient of variation in endocranial capacity for the australopithecines and *Homo habilis* would

be any different (Lockwood and Kimbel, 1999), and we do not know the sex of the crania in this study, encephalization quotients will be calculated using numbers that represent the widest range of calculated body masses for both male and female published in the literature. Also, since it has been demonstrated in this paper that the hominids in question are facultative bipedal, body masses originating from the hominoid model will be used to calculate the encephalization quotients and then compared to corresponding quotients originating from the human model. The final numbers should then represent the widest statistical scope of encephalization quotients conceivable from known published data.

Figure 2 is an interval plot comparing the encephalization quotients of *A. afarensis* and *Homo habilis* using human and hominoid body mass estimates, respectively. The first interval plot (Figure 2A) uses human body mass estimates and produces encephalization quotients that result in a p-value of 0.037. A p-value this low rejects the null hypothesis and says that within a 95% confidence, *Homo habilis* is more highly encephalized than *A. afarensis*. The second interval plot (Figure 2B) uses hominoid body mass estimates and generates a p-value of 0.128. A p-value of 0.128 accepts the null hypothesis and says that within a 95% confidence, *Homo habilis* is not more encephalized than *A. afarensis*. So by changing the human model to the hominoid model to accurately represent the facultative bipedalism of *Homo habilis* and *A. afarensis*, the calculated encephalization quotients of both creatures are statistically inseparable.

Sexual Dimorphism

An encephalization quotient is calculated as a corrected ratio of brain mass to body mass for a particular organism. However, Table II demonstrates the well-known fact that the australopithecines and *Homo habilis* are sexually dimorphic (Johanson and White, 1979; McHenry, 1986; 1991a; Zihlman, 1985). Since body mass is in the denominator of the ratio in question, it is the low body weight of the dimorphic female that is the primary contributor to a higher calculated encephalization quotient. Given that the sex of very few (if any) fossilized crania of these creatures is known, it is possi-

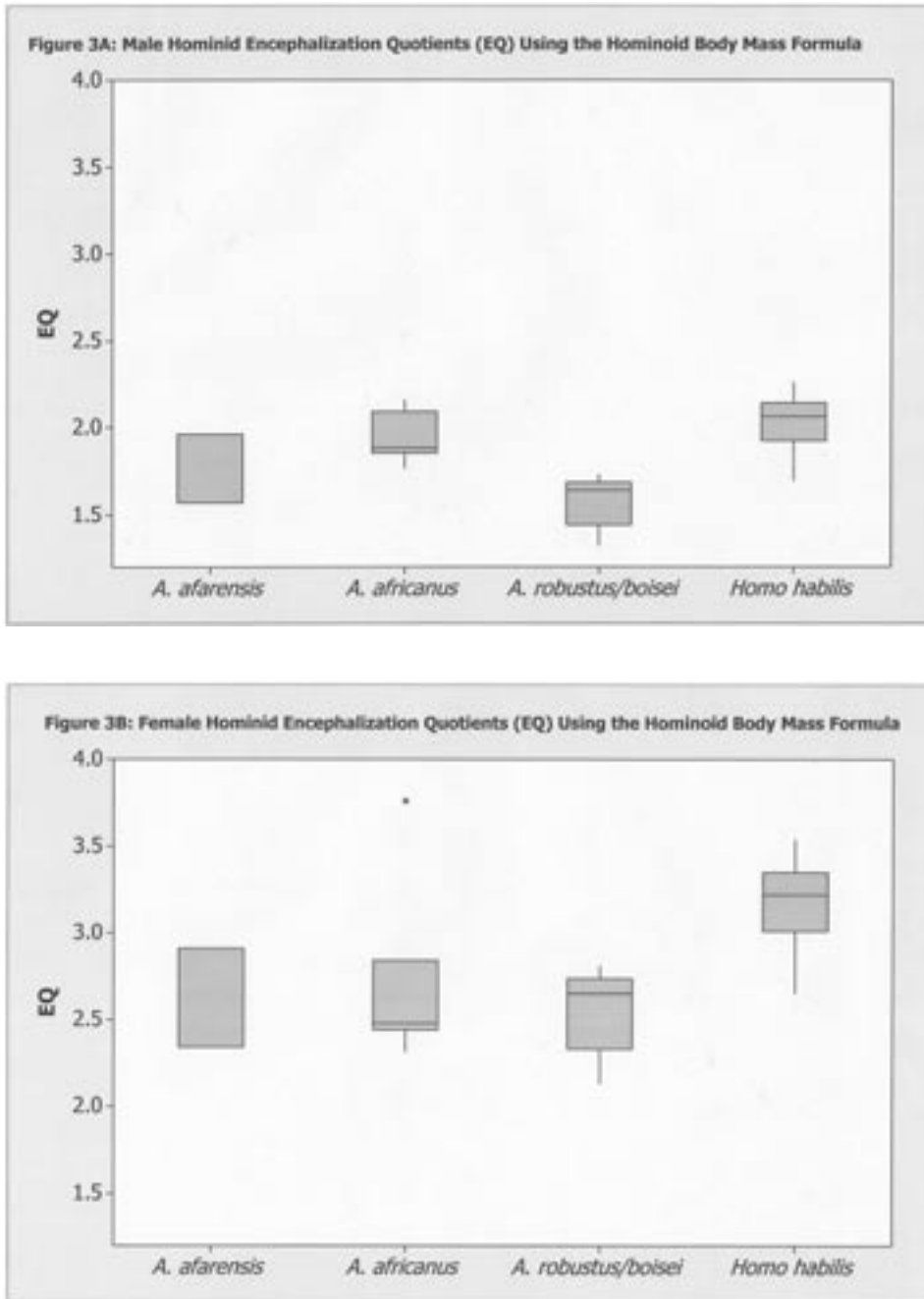


Figure 3. Male (A) and Female (B) hominid encephalization quotients using the hominoid body mass formula.

ble that all known specimens (or a majority) could originate from only one of the sexes. Figures 3A and 3B are box plots of the australopithecines and *Homo habilis* encephalization quotients using male and female calculated bodyweights, respectively. Figures 3A and 3B demonstrate that the primary origin of the perceived degree of encephalization increase of *Homo habilis* over the australopithecines is from the calculated body weight of the sexually dimorphic female.

When only male calculated bodyweights are used (Figure 3A), the encephalization quotients of the australopithecines and *Homo habilis* are essentially the same.

Australopithecines and Pan-Troglodytes

Evolutionists have also presented data comparing the ratio of brain mass to body mass (using the human model) versus evolutionary time as an attempt to demonstrate that extinct australopithecines are a more highly evolved version of the pan-troglodytes. Figure 4 is a scatter plot comparing the ratios achieved when using body masses originating from both the human and hominoid models. When the hominoid model is used to calculate the ratio of brain mass to body mass, the degree of brain expansion of the australopithecines and pan-troglodytes are essentially the same.

Australopithecines and *Homo habilis*

The coefficient of variation for brain mass of *Homo habilis* is 9.14% (n=7). Lockwood and Kimbel (1999) have stated that there is no reason to believe that the coefficient of variation for these extinct creatures should not be as wide as 15%, just like extant humans and apes. Statistically, this means that *Homo habilis* could have a brain mass of 405 grams and still have a coefficient of variance less than 15%. A *Homo habilis* brain mass of 405 grams is well within statistical variation of brain masses calculated from australopithecine fossilized crania. Hence, when proper body mass estimates are utilized and data are corrected for known statistical variation, these extinct creatures (*A. afarensis*, *A. africanus*, *A. robustus/boisei*, *Homo habilis*), are shown to have the same degree of encephalization as extant species of apes.

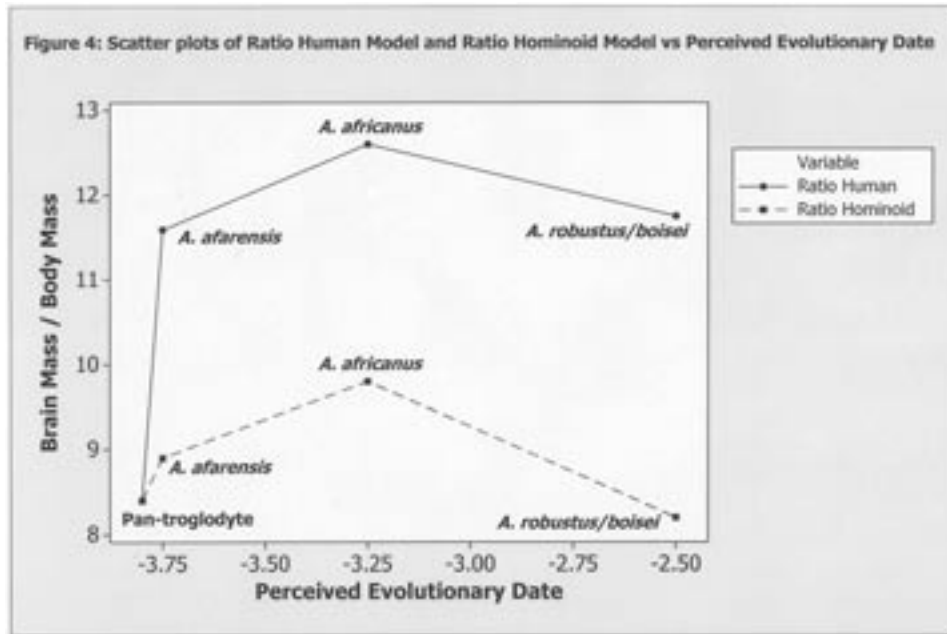


Figure 4. Scatter plots of the ratio human model to ratio hominoid model versus perceived evolutionary date.

Summary

All of the australopithecines including *Homo habilis* are facultative bipedal with brachiation as a primary mode of locomotion. Their terrestrial bipedalism is heavily dominated by a postural component. A brachiating animal must have more mass in the upper body than obligatory bipeds (humans) because of their primary locomotion repertoire. A model for calculating body mass that only includes obligatory bipeds would be skewed to an abnormally small value because of the obvious upper body mass differences of a facultative biped compared to an obligatory biped. Hence a model that includes data from animals that practice brachiation, etc. would more accurately predict the true body mass of the australopithecines and *Homo habilis*.

When a body mass model based on McHenry's (1992) hominoid data is used in encephalization quotient calculations, the brain advancement of *Homo habilis* and the australopithecines is statistically the same. Evolutionists have embraced *Homo habilis* as the first step upward in brain mass that eventually led to humans. Within statistical error, when body mass calculations are corrected for (1) a primary locomotor strategy of brachiation, (2) a terrestrial bipedalism that is postural, and (3) known sexual dimorphism, it is no more encephalized than the australopithecines and pan-troglodytes.

Australopithecines are generally labeled as "hominids" because there are features they lack that are epitomized

in the living apes and they exhibit what is interpreted as humanlike attributes. However, it is frequently argued that their perceived humanlike characteristics might just be primitive because many of these characteristics are found in premature African apes. They certainly are not more encephalized than extant chimpanzees. Therefore it is more probable that the australopithecines are phylogenetically connected to African apes and should not be considered an evolutionary transitional link toward becoming humans (Kleindienst, 1975; Goodman, 1982; Oxnard, 1975; Hasegawa et al., 1985; Edelman, 1987; Verhaegen, 1990; 1994).

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