matters arising

Fossil hominid femora

McHenry and Corruccini used a canonical variates analysis to assess the affinities of five early hominid femora[1], two of which are complete (ER 1472, 1481, although the head of the former is damaged). The fossil hominids appeared to separate from living *Homo* on the fourth variate axis, accounting for only 4.7% of the variation. Nonetheless, the authors conclude that "there were at least two distinctive forms of hominids" represented. The authors state that head size is "heavily weighed" on this axis and suggest "large femoral heads might be the result of a widened birth canal." Yet, differences in femoral head size must be related to bone length to be meaningful and unambiguous; larger specimens will probably have larger heads.

Have they truly determined a relative head size variable? They argue that the femoral dimensions are adjusted using average within-taxon allometry coefficients "between each measurement and a standard size variable". But which coefficients might be used to standardise the early hominid measurements is problematic, for these combine relative neck length and shaft thickness dimensions which are unknown for any other hominid taxon, except possibly *H. erectus*.

Because they divide head diameter by neck length or shaft thickness, there is confusion about whether the head is relatively small, or the neck and shaft are relatively large. This underlies the different estimates of bone length in fragmentary early hominid specimens. For instance, McHenry[2] rejected an estimate of early hominid femoral length based on a regression from head size[3] because, he argued, the heads are relatively small. Yet, he used a multiple regression to predict bone length giving much longer determinations based in part on neck length[2], although later realising that the necks are relatively long[1]. Thus, the necessity of relying on those few specimens with known or reconstructable shaft lengths is underscored: shaft length is the only size measure which does not require choice between neck or other shaft measures to estimate size in an analysis intended to determine whether or not the heads were relatively small. Unfortunately, only one published specimen requires no reconstruction to avoid this circularity (ER 1481), although three others make possible additional estimations.

Table 1 Biomechanical neck length and head diameter relative to femur length in a sample of 50 Libben Amerinds

	Relative biomechanical neck length	Relative head diameter
Mean ± (s.d.)	0.154 (0.008)	0.100 (0.005)
Maximum	0.177	0.114
Minimum	0.135	0.091

These data were provided by C. O. Lovejoy.

When 50 males and females from the Libben Amerind collection (Table 1) are used for comparison, relative biomechanical[4] neck length for ER 1481 is 3.25 standard deviations above the Libben mean, and relative head diameter 1.80 standard deviations above the mean (Table 2). The next best specimen is ER 1472. Length is known but damage to the head prevents accurate head or biomechanical neck length measurements. As preserved, relative neck length is too short, but is still 1.00 standard deviation above the Libben mean. The only other specimen that can be considered is STS 14, a very damaged proximal femur with a reconstructed length of 285 mm (ref. 5). (The estimate used here adds a portion of the head diameter inadvertently left off the published length of 276mm). The neck is broken just before the junction with the head and has been repaired, although not reconstructed with plaster. The head diameter is reconstructed, but constrained because it must fit the associated acetabulum. Relative neck length is 3.25 standard deviations above the Libben mean, and relative head size 1.80 standard deviations. No attempt has been made to reconstruct femur length in other specimens with heads, since the various shaft diameters show a very low correlation with length in specimens with known or reconstructable lengths.

Table 2 Relative biomechanical neck length and head diameter in early fossil hominids compared with Libben

	Relative biomechanical neck length		Relative head diameter	
	Calculated	Difference from Libben mean in s.d.	Calculated	Difference from Libben mean in s.d.
ER 1481	0.180	+3.25	0.109	+1.80
ER 1472	>0.162	> +1.00		
STS 14	0.182	+3.50	0.109	+1.80
ER 999	0.164	+1.25		

These measurements were taken by me.

ER 999, from above the Chari tuff, (1.34 Mys) is probably *H. erectus*; the relative neck length is 1.25 standard deviations above the Libben mean.

In sum, for all the known or reasonably reconstructable specimens, neck length is relatively very large compared with living humans and

Table 3 Comparison of innominate measurements normalised to acetabulum height

	Libben mean	σ	Distance from Libben mean in s.d. STS 14	SK 3155	SK 50	OH 28
Ratio to acetabulum height of:						
Ilium height	2.33	0.14	+2.8	> +3.4*		
Greater sciatic to anterior notch	1.37	0.08	−2.3	−0.05	+0.46	−1.52
Anterior inferior to ischial spine	1.98	0.09	−1.3	−2.2		−2.9
Anterior inferior to posterior superior spine	2.57	0I14	−2.4	1.7		−0.4
Functional length of ischium	1.45	0.08	−3.8	−4.9	−0.8	−4.5

These measurements were taken by me. The functional length of the ischium[4] is measured on both the Australopithecines and the Libben sample; the breaks on the STS 14 ischium and on the SK 3155 ischium minimise the measurement. The Libben sample size is 30. That some of these measures which cross, or almost cross the acetabulum differ considerably from the Libben mean when normalised by acetabulum size further emphasises the differences in proportion; when normalised to the acetabulum the iliac blades are relatively large and most other measures small, but normalised to the ilia everything else is extremely small.

*Addition of the unfused iliac crest would make this larger.

relative head size is, if anything, above the human mean[6]. These head, neck and shaft length relations are shown by two femora attributed to *"Homo,"* and one attributed to *"Australopithecus."* Moreover, judging from the published photographs they also characterise the complete Afar hominid femur attributed to *"Australopithecus"*[8]. Former claims of relatively small head size come from comparison of head diameter with shaft diameter in incomplete specimens. Analysis of femora of known or reconstructable lengths shows that the shaft diameters were relatively large.

The demonstration that the heads were not relatively small calls to question the claim that the acetabula were relatively small[1], since of all pelvic dimensions the acetabulum has the highest correlation with femur length (0.840 for 30 Libben Amerinds). Schultz[7] demonstrated the large relative size of the STS 14 and reconstructed SK 50 acetabula. When various comparable innominate measurements are normalised to acetabulum height (Table 3), and compared with the Libben sample, only relative ilium height is consistently above the Libben mean, as expected given the greater amount of iliac flare in the early hominids[4]. Iliac breadths are generally below the Libben mean, except for one measure of SK 3155, and contrary to "conventional knowledge", the functional length of the ischium is relatively short. The *H. erectus* innominate follows the australopithecine pattern. Only if normalised to iliac height would the early hominid acetabulum appear relatively small, and the other measurements would be relatively yet further below the Libben mean. Given the above, it is far more likely that australopithecine acetabula are human-like relative to body size, and the ilia are relatively long.

In sum, the distinguishing features of the early hominid hip complex reveal a pattern of form differing from living humans because of a combination of narrower birth canal and markedly greater muscular activity, but not differing in locomotor capacity.

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1 McHenry, H. M., and Corruccini, R. S., *Nature*, **259**, 657–658 (1976).
2 McHenry, H. M., *Am. J. phys. Anthrop.*, **40**, 329–340 (1974).
3 Burns, P. E., *Nature*, **232**, 350 (1971).
4 Lovejoy, C. O., Heiple, K. G., and Burstein, A. H., *Am. J. phys. Anthrop.*, **38**, 757–780 (1973).
5 Lovejoy, C. O., and Heiple, K. G., *Am. J. phys. Anthrop.*, **32**, 33–40 (1970).
6 Walker, A. C., *J. human Evol.*, **2**, 545–555 (1973).
7 Schultz, A. H., *Folia Primat.*, **11**, 181–199 (1969).
8 Johanson, D. C., and Taieb, M., *Nature*, **260**, 293–297 (1976).

McHENRY AND CORRUCCINI REPLY—The discussion here[1] is about different fossils. We show that taken together the relative proportions of the proximal ends of KNM-ER 1481 and 1472 are distinguishable from those of SK 82 and 97 and KNM-ER 1504. Wolpoff argues[1] that the reconstructed femoral head diameter and neck length relative to reconstructed femoral length in Sts 14 are similar to KNM-ER 1481. We feel that a meaningful and unambiguous argument should not be based upon measurements of a fossil (Sts 14 femur) described as "a useless jumble of glued fragments surmounted by a crude plaster head and neck"[3]. Nor should the length of a half missing ischium (SK 3155)[4–6] be used to bolster such an argument.

A few points need to be clarified. (1) Our analysis is based on both univariate and canonical variates analysis and the results agree. (2) The variation on the fourth canonical variate is not interpreted by us as the result of femoral head size only. In fact, greater trochanter projection has the highest correlation with that variate, followed by neck length and femoral head size. The canonical variate is complex, reflecting the complexity of interrelationships among the variables. (3) Because variance scales to the number of subjects, one would not expect a high percentage of variance on the fourth canonical variate. The fourth variate contributes substantially to the multivariate distances between subjects. (4) KNM-ER 1481 does indeed have a relatively big head, which is just our point because it represents the *Homo* taxon. The ratio of femoral head size to length in KNM-ER 1472 is 0.10 (ref. 7), which is exactly the Libben mean. This specimen is also classified as *Homo*. The only specimen classified as *Australopithecus* to which Wolpoff refers in regards femoral head size and length is Sts 14, but this specimen is missing both its head and its distal end[8]. (5) Walker[9] did not conclude that the "relative head size . . . is above the human mean". He showed that his composite and reconstructed australopithecine femur has a ratio of head size to length slightly below the human mean.

In our view canonical variates analysis is one more useful tool for analysing complex biological shape. The method allows one to take into account variability within taxa, it reduces the complexity of interrelated shapes and sizes to understandable dimensions, and it allows an anatomical region to be treated as a total complex (inasmuch as the available fossil material will allow).

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1 Wolpoff, M. H., *Nature*, **264**, 812–813 (1976).
2 McHenry, H. M., and Corruccini, R. S., *Nature*, **259**, 657–658 (1976).
3 Day, M. H., *Symp. zool. Soc. Lond.*, **33**, 29–51 (1973).
4 McHenry, H. M., thesis, Harvard Univ. (1972).
5 McHenry, H. M., *Am. J. phys. Anthrop.*, **43**, 245–262 (1975).
6 McHenry, H. M., *Am. J. phys. Anthrop.*, **43**, 39–46 (1975).
7 Day, M. H., Leakey, R. E. F., Walker, A. C., and Wood, B. A., *Am. J. phys. Anthrop.*, **42**, 461–476 (1975).
8 Robinson, J. T., *Early Hominid Posture and Locomotion* (University of Chicago Press, Chicago, 1972).
9 Walker, A., *J. human Evol.*, **2**, 545–555 (1973).