

Why are women smaller than men? When anthropology meets evolutionary biology

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There are large variations of size among humans but in all populations, men are larger on average than women. For most biologists this fact can be easily explained by the same processes that explain the size dimorphism in large mammals in general and in apes in particular. Due to fights between males for the possession of females, sexual selection has favoured bigger males^{1,2,3}. Indeed, this factor certainly explains why males are selected for being large but lets aside the question of selection on the female side. Actually, it has been shown that larger females are also favoured by natural selection. This is particularly relevant for women because their probability of dying when giving birth is then reduced^{4,5,6}. In this paper, the common view that size dimorphism in humans results from the fact that the advantage of being big is stronger for men than for women is challenged by another hypothesis, namely that the difference results from a difference of cost rather than from a difference of benefits. The cost of being big would be higher in women simply because, under gender hierarchical regimes found in all cultures, men are allocated the best food. The interaction between evolutionary forces and cultural practices could then lead to this disadaptive situation.

Being large is undoubtedly advantageous for men but also for women. Concerning men, the advantage is usually supposed to involve survival and/or reproductive output

(through competition between men, whatever the form it takes)^{1,2,3}. Concerning women, an important component is the fact that the probability of death of both the mother and the child decrease with the size of the mother^{4,5,6}. The fact that there seems to exist a stable body size while there is heritable variation for this trait indicates that the advantage stated above is compensated for by a cost. This cost is probably at least partly due to the fact that increasing the body size involves a higher resource acquisition but can also involve different kinds of scaling effects like the surface/volume ratio which decreases as the size increases. The expected individual size should be determined by the point where the cost and benefit curves cross. This point is stable if the benefit is lower than the cost when the size is below this point and reciprocally (Fig. 1.).

The existence of a dimorphism indicates that at least one of these two curves (benefit or cost) is different according to the sex of the individual, or at least has been different in the past. Indeed, such a dimorphism is found in all human populations⁷. One could imagine that this dimorphism is simply a remnant of an old one, which existed at the time of our common ancestor with say Gorillas^{8,9}. However, this hypothesis can be rejected because (i) the degree of dimorphism is variable among populations and families^{10,11} and (ii) this variation is heritable¹². Given these facts, the present situation cannot be simply the perpetuation of the preceding one. Selection should be able to shape efficiently the size dimorphism in humans^{6,13,14}.

The classic explanation favoured by biologists is that dimorphism results from a difference between males and females in terms of benefit of being large. Fig. 2. shows such a case. Indeed, an increased size is beneficial in terms of fitness both to males and females. But the increase of fitness being higher for males than for females, a similar cost for both sexes leads to an “equilibrium” situation where males are bigger than females. This explanation certainly holds for a lot of big mammals, including apes because individual fights remain an important factor in the determination of social status

and access to females concerning the males^{15,16,17}. This explanation has thus been critically discussed for different classes and orders of animals^{18,19} and particularly for the primates order^{20, 21,22,23,24}.

In humans, it is likely that this very factor has long been less important than in other species. Indeed, numerous authors have stated that other environmental factors are involved, nutrition being one of them^{14,25}. Anthropological data about the non egalitarian access to resources that characterizes human societies could explain the same fact. This suggests that we should start thinking in terms of differences in costs rather than in terms of benefits. It has been shown that in almost all known populations worldwide, restrictions are very often targeted at the critical period of a woman's reproductive lifetime²⁶, and women as a group are supposed to get less food in terms of quantity and of quality than men do^{25,27}. This reality is expected to be the direct consequence of an institutionalized inequality in favour of men that the social sciences have named the gender order²⁸. Even if the benefit of being big is as great for women as it is for men, and even if there is not any advantage in being big for men anymore, this difference of resource allocation would generate a difference in cost which can explain the size dimorphism (see Fig. 3.). This hypothesis holds for humans and perhaps for some primates where females have no priority for access to resources²⁹, contrary to what happens for some monomorphic primates³⁰.

It is thus suggested that, in humans, the differential cost associated with growth in males and females is different, thanks to the unequal sharing of resource between males and females. This would generate a dimorphism even in the absence of differences of benefits associated with increased size between the sexes. In order to test this hypothesis against the "standard" model, one would need to determine the curves of cost and benefits for males and females in different conditions. A precise knowledge of these curves would certainly be difficult to reach but it is probably possible to find orders of

magnitude of variation. Note that the two hypotheses are not exclusive and if they are both true, the effect will be even greater. It is interesting to notice that in our hypothesis, the fact that females are smaller than males is far from being optimal. Given that the reproduction is physiologically realized by women, there would have been incredibly less child and mother damage in human history if females have had access to a richer diet: the cost of growing more would be decreased and they would reach a size which allows them to give birth with a decreased probability of accident and depletion. Furthermore, from a demographic point of view, this situation would be more favourable for the population. There has always been in the literature a strong tendency to interpret cultural affairs in terms of biological success. Such biological arguments have long been used to justify unfair social rules. The present case could constitute a counter-example where a cultural trait is counter-adaptive because of its evolutionary implications.

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Fig. 1. The evolutionary stable size of an individual is determined by the point at which the cost becomes higher than the benefit.

Fig. 2. The classical interpretation of size dimorphism in mammals involves a difference of benefit according to the sex of the individual. Although both sexes benefit from a larger size, the advantage is higher for males than for females.

Fig. 3. The proposed hypothesis is that, due to unequal sharing of resources between males and females, the cost of a large body size is higher for females; this leads to a size dimorphism even if the benefits provided by a larger size are equal for males and females or if the benefit for males is lower than for females.

Fig. 1.

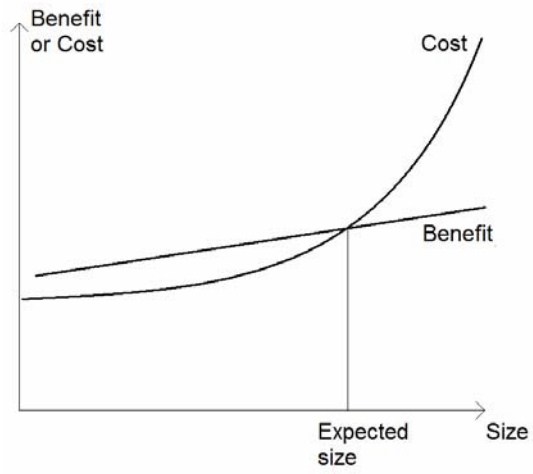


Fig2.

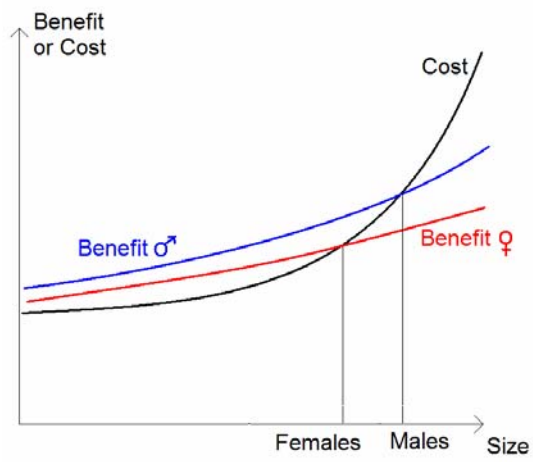


Fig 3.

