HAL
open science

Violence against women in an evolutionary context: is the gender system a cause of dystocic labor in modern humans?

Pierre Frémondière, Lionel Thollon, Hassler Pascale, Sebastien Riquet, Carole Zakarian, François Marchal

To cite this version:

Pierre Frémondière, Lionel Thollon, Hassler Pascale, Sebastien Riquet, Carole Zakarian, et al.. Violence against women in an evolutionary context: is the gender system a cause of dystocic labor in modern humans?. Journal of Humanities, Arts and Social Science, 2022, 6 (2), pp.248-261. 10.26855/jhass.2022.06.013 . hal-03838478

HAL Id: hal-03838478

https://hal.science/hal-03838478v1

Submitted on 3 Nov 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

"This is the pre-peer reviewed version of the following article: « Violence against women in the an evolutionary context: is the gender system a cause of dystocic labor in modern humans », which has been published in final form at https://www.hillpublisher.com/UpFile/202207/20220707160253.pdf. This article may be used for non-commercial purposes

Violence against women in the evolutionary context: is the gender system the source of dystocic labor in modern human?

Pierre Frémondière[1,2,*], Lionel Thollon[3], Hassler Pascale[1], Sebastien Riquet[1], Carole Zakarian[1],François Marchal[2]

[1]Aix Marseille University, School of Midwifery, Faculty of Medical and Paramedical Sciences, 51 boulevard Pierre Dramard, 13344, Marseille cedex 15, France[2]UMR 7268 ADES, Aix-Marseille Université, CNRS, EFS, Secteur Nord Batiment A, CS80011 Bd Pierre Dramard 13344Marseille Cedex 15, France.

[3]LBA INRETS, Aix-Marseille Université, Secteur Nord Batiment A, CS80011 Bd Pierre Dramard 13344 Marseille Cedex 15,France.

Abstract

Violence against women is one of the most widespread violations of human rights in our world today. The gender system, an institutionalized system producing different roles for women and men, could be the source of a system of oppression of women that generates gender-based violence. Cultural practice affected by the gender system, such as food sharing, may explain biological difference between men and women. According to the "Nutritional Constraints on Women's Size Selection" (NCWS) hypothesis, body size difference between men and women coud be explained by the women's limitation to the food access throughout human evolution. This hypothesis is investigated in this paper, through new insights from primatology, evolutionary anthropology and auxology. Based on their analyses, we suggest that sexual dimorphism, where males are bigger than females, is a primate condition rather than the result of the inequality in the food access. NCWS hypothesis suggests that nutritional constraints result in a limitation of growth and produce small pelvis. This would explain why modern humans exhibit a high frequency of fetal-pelvic disproportion resulting in a high maternal mortality without medical assistance. But previous works show that the pelvic shape is adapted to the parturition in different ciconstances (small bodied women, reproductive age). For these reasons, we suggest that the emergence of the gender system is not related to the specific obstetrical conditions of modern humans. Other hypotheses such as the obstetric dilemma or the energetic for growth and gestation bring specific explanations to the human birth patterns.

Count 246/250

Keywords

Pelvis, shape, obstetrics, domestic violence, gender system, diet.

38

Main text:

1 Introduction

The gender system is an institutionalized system involving unequal social relations between male and female. As a multilevel system of difference, it is based on cultural beliefs and unequal distribution of resources (Ridgeway & Correll, 2004). The consequences of the emergence of this system on the sexual body size dimorphism are questioned in this article. Evolutionary pressures have shaped human bodies during complex processes implying cultural, environmental and biological changes. Among cultural changes, social systems including cooperative or competitive and violent behaviors are supposed to explain some of our anatomical patterns (Shea, 1985; Plavcan and van Schaik, 1997). Some authors hypothesize that the inequal distribution of food ressources between males and females acts during human evolution and leads to the sexual dimorphism in body size seen in extant humans (Wolfe & Gray, 1982; Touraille, 2005). In this hypothesis called "Hypothesis of Nutritional Constraints on Women's Size Selection" (NCWS) (Touraille, 2013) the emergence of the gender system at an early stage of human evolution would generate this unbalanced food distribution. The suggested biological consequences are : 1) a smaller stature for females, 2) a reduction of the size of their pelvises and 3) an increased risk of experiencing difficulties (dystocia) at birth. Such a scenario is intriguing since it combines different aspects of human biology; *e.g.* sexual dimorphism in body size, growth process, pelvic sexual dimorphism, obstetrics, with a behavior (food sharing practice) that could be highly variable today.

First, the aim of this work is to present this NCWS hypothesis in the large context of primates (sexual dimorphism, mating system), evolutionary perspectives (obstetric dilemma hypothesis, energetic for gestation and growth hypothesis) and health (birth dystocia) and social issues (violence against women). The first part of this review adresses the question of the origin of violence that could leads to the VAW today and the inequal distribution of food ressources, the cornerstone of the NCWS hypothesis. According to this hypothesis, specific behavior resulting from the emergence of the gender system explains sexual body size dimorphism in human. This gender system implies complex relationships between males and females since it requires a system of "self-evidence". Such a system is certainly absent in non-human primate and we expect to find highly variable sexual body size dimorphism among primates according to the NCWS. Therefore, the second part of this work lies on the sexual body size dimorphism in primates. Finally, the NCWS posits that sexual body size dimorphism is disavantageous for females, leading to a high rate of mortality during the birthing process. In this work, we therefore aim to find if the sexual body size dimorphism generates difficulties during childbirth in modern humans.

2 The representativeness of violence in humans, and its consequences in sexual dimorphism

2-1 Human violences and the sharing of resources.

In 2014, the violence in all its forms (self-directed, interpersonal and collective) accounts for 2.5% of global mortality worldwide, and represents the cause of the death of more than 1.3 million people. WHO estimates that 475000 people were victims of homicide. Rate of homicide is not distributed equally between sex and age: most of the victims of homicide are male (four times the rate of homicide of female) and young people (the highest estimated rates of homicide are for the group age of 15-29 years) (WHO, 2014). However, providing a complete view of human violence is difficult given its multiple forms *i.e.* political violence (Zwi, 1982), intimate partner violence (García-Moreno et al., 2005), child maltreatment (Danese & Widom, 2020), *etc*... The presence of violence in human societies could be related to our primate inheritance. Among mammals, primates widely used violence in their social relationships to ensure the reproductive success (Muller et al., 2007), or maintain a well-defined hierarchies within the group (Flack & de Waal, 2004) despite the cost for the victim in term of increased glucocorticoid secretion (Muller et al., 2007). Today, different levels of violence exist among human societies. Surprisingly, western societies may exhibit particulary high level of interindividual violence, in comparison with hunter-gathered societies. As well, many human societies, particularly those with low distinction among individuals and low population density, such as the Aka peoples or the Ache of Paraguay, share resources (hunted or gathered foods) and are based on a collaborative system between individuals. In these societies, where leadership is rarely a matter of competition (Knauft, 1991), "sharing" is a social imperative that structures different aspects of the life in the group (Spikins, 2019), which generates peaceful relations between individuals.

In the evolutionary context, the consequences of cultural practices on biological or anatomical patterns cannot be investigated reliably, except if the body retains the mark of a specific human activity. Skeletal evidences suggest that different forms of violence exist in the past (Goetz, 2010; Tung, 2012). Violence could have been used to solve adaptive problems, thus explaining the distribution of polymorphic traits in modern human population. For example, an intriguing but highly speculative hypothesis suggests that the representativeness of left-handers in human population could be related to fighting advandages (Raymond *et al.*, 1996). A potential cause of the emergence of the violence in human societies is the transition between "simple" hunter-gathering and agricultural/sedentary systems. While human societies, such as nomadic foraging or forager-horticulturalists societies, exhibit a less decentralized and a more egalitarian social organization, "complex" hunter-gathered, more specifically sedentary societies, would possess a system of rank distribution that could generate tensions among individuals. This condition of relaxed social tension in foraging societies is supposed to be a persistent condition throughout *Homo sapiens* evolution. This evolutionary scenario assums that the trajectory of human violence throughout human evolution has a U-shaped, where the extermities of this trajectory are represented by the violent societies of non-human primates (which depicts the hypothetic societies at the first step of human evolution) and the sedentary, ranked human societies (a social organization that is supposed to appear after the neolithic transition) (Knauft, 1991).

NCWS hypothesis suggests the emergence of a complex social organization, where individuals are ranked according to their gender. Access to food is dependent of the status of the individual according to this rank. In addition, sharing practices are more frequent in peacefull societies where social organizations are more egalitarian. This would suggest that inequal distribution of ressources due to an arbitrary status (e.g. gender), would appears or be emphasized at a late stage of human history, with the emergence of complex social organization. While violence in human societies does not seem to be exclusively the result of our primate condition, is male aggression against females a specific primate pattern?

2-2 Males aggression against females in primates and evolutionary perseptives

In humans, gender violence, also named Violence Against Women (VAW) is an important public health issue today. VAW is geographically widespread: in 48 population-based studies from around the world, between 10% and 70% of women reported suffering from domestic violence during their lifetime (Heise *et al.*, 1999). According to WHO, the range of ever-partnered women who suffered physical violence by an intimate partner is from 13% in Japan city to 61% in Peru province, with most sites falling between 23% and 49% (García-Moreno *et al.*, 2005). Futhermore, VAW has various aspects: from the gender pay gap to the domestic violence, VAW is now largely recognized as part of a broad-scale system of domination that affects women as a class (Schechter, 1982).

Estimating the relationships between males and females during human evolution is difficult and almost speculative. However, some interpretations of the male-female interaction have been proposed based on the observation of mating strategies in non-human primates, and several patterns of sexual dimorphism observed in extinct hominins. In non-human primates, mating strategies could be identified according to different levels of male-to-male competition. For example, gorillas or baboons exhibit high level of male-to-male competition (Baniel et al., 2017; Wright et al., 2019). In such mating system, primates are expected to show more male-to-female aggression than species living in monogamous groups because polygyny is often associated with much more intense male-to-male competition for mates (Smuts and Smuts, 1993). Moreover, specie that shows high level of male-to-male competition exhibits high level of body size and canine sexual dimorphism. Among these dimorphic traits, canine crown height dimorphism is strongly correlated with estimates of intrasexual competition (Plavcan and van Schaik, 1997). When considering the dimorphism of *Australopithecus africanus* and *Australopithecus robustus*, the estimated mating system for these early hominins is characterized by low-intensity of male–male competition (McHenry, 1992; Plavcan and van Schaik, 1997). While some estimators, such as canine occlusal dimorphism, offer apparently little information about mating system, these results suggested that Australopithecines would have a mating system with low level of male-to-male competition, and they likely experienced low level of male-to-female aggression. This may indicate that the relationships between male and female were peaceful at the early stages of human evolution. However, in recent human history the preservation of the skeletal remains (which are almost complete in comparison with the state of preservation of hominin's remains), and the archaeological evidences offer the opportunity to improve our understanding of the status of women in ancient societies. In contradiction with the early stages of human evolution, some evidences suggest that women were the victims of social oppression. For example, in the site of Conchopata (Peru), the

remains of an old woman are strongly associated with the scenario of a life history of a battered female in the seventh century AD (Tung, 2012). In other archeological sites, anthropologists found a significant proportion of women and children in a probable context of massacre (Armit, 2011) or evidences of maltreatement in captive women (Martin *et al.*, 2010).

Mating system seems to affect certain aspects of sexual dimorphism. But among the potential sources of sexual dimorphism, nutritional factors are rarely investigated (Touraille, 2013). NCWS posits that the inequal access to food is inolved in the sexual body size dimorphism. This hypothesis is intriguing since the distribition of food between males and females seems to be highly variable today. What are the sociological evidences of the inequality of food distribution and their potential effects for sexual dimorphism?

2-3 The inequality of food distribution between males and females in an evolutionary context

The gender system is a social system that determinates the number of gender and the role of each gender (Nanda, 1998). The gender system rules many activities in human societies. According to Touraille (2008), this is a system of oppression combined with a "system of self-evidence". For example, in this system, a question about the reason of the difference between male/female activities is followed by the stereotypical answer: "it has always been like that". Among the activities strongly codified in human societies, food sharing and meal-time rituals are affected by the gender system. Many societies proceed to an order in the division of animal protein for which women are negatively discriminated. This is the case in the study of Atse and Adon (2015), where this unequal sharing in the rural population of Akyé is based on ideologies from food myths. For example, Akyé women are not allowed to eat doe since a traditional cure, made off byproduct of doe (*i.e*. kaolin), is used in case of infertility. In turn, the consumption of doe leads to the risk of female infertility in the Akyé belief (Atse and Adon, 2015). This example illustrates how magical thinkink contributes to the food sharing discrimination, with the system of self-evidence. Other examples of food sharing discrimination exist in the world. In rural population of Greece, when there is not enough meat or even tomatoes in the diet composition of a family, a woman usually leaves her portion for her husband or her son (Fournier *et al.* 2015). The gender system is supposed to unconsciously rule the process of food sharing. There is a large range of variability in the cultural food practices among human societies. These cultural food practices may have an impact on the growth process and ultimately on body size. For instance, Richards (1932) describes the inequality of the food distribution between males and females in a Bantu sample. In this study, the author shows that biological aspect of diet is closely related to sociological patterns: the family structure and the relationship between family members affect food practices. An inequality in meat or protein intake could occur in human societies. For the Hadza population, diet for male includes 39,6% of meat versus 1,2% for female (Marlowe, 2010). Dietary protein has long been known to increase growth and adult body size. For example, dietary protein increases circulating levels of growth factor such as the insulin-like growth factor-1 (IGF-1) (Schurch *et al.*, 1998). The inequality in the composition of diet explains, for some authors, the dimorphism in body size (Jolly, 1984; Touraille, 2005). It would explain the difference of 2,5 to 7 inch of body size between males and females. However, dietary protein is not the only factor that contributes to growth efficiency. Protein increases urinary calcium losses (Dawson-Hughes, 2003). Since the calcium losses have a negative impact on the bone mineral density, an adequate calcium intake may help promote a favorable effect of dietary protein on the bone mineral density (Meyer *et al.*, 1997; Dawson-Hughes, 2003) and the growth process.

Evolutionary sociologists hypothesize that the access for food would be reduced for female given the gender system oppression. Understanding VAW in an evolutionnary context was previously attempt in several reports (Wilson and Daly, 1993; Peters *et al.*, 2002; Campbell, 2012) For example, Wilson and Daly (1993) suggest that one goal of VAW is to deter female infidelity. These studies questioned the origin of VAW. Others hypotheses are related to the impact of VAW during evolution, and its consequence for the sexual dimorphism. Many authors underline the role of sexual dimorphism on the mating system: the competition between males for the reproductive success selects bigger males and increases intraspecific sexual dimorphism (Wolpoff, 1976; Plavcan and van Schaik, 1997). For Sentell (2015) the increase of sexual dimorphism during human evolution emphasizes the vulnerability of female to "male power". For some authors, a distinction exists between sexual selection and natural selection. This distinction explains the promotion of an anatomical trait useful for reproduction (advantageous trait for sexual selection) but disadvantageous for the species (disadvantageous for natural selection). Among these anatomical traits, size of human males is supposed to have inflicted damage to female bodies. NCWS hypothesis suggested that males became bigger than females or females smaller than males, because of male-male competition. This competition selects males with aggressive behavior and inclines

to the restriction of food access for the females. This restriction in turn increases sexual dimorphism and female vulnerability. Moreover, the female pelvis and the female body size are supposed to change allometrically. Then the birth canal became less-adapted to the delivery of a normal sized neonate. This incompatibility in size between neonate and birth canal, also called "fetal-pelvic disproportion", is suggested to have increased female mortality during human evolution.

NCWS hypothesis posits that inequality in food distribution emphasizes the difference in growth potential between male and female, leading over multiple generations to a stabilization of size difference between male and female (Touraille, 2013). The main consequence today is the inequality in the food access as reflected in sociological or ethnological evidences. Morevover, the decreasing size of the female pelvis, relative to the size of male, would generate more risk of fetal and maternal death due to the complexity of the birthing process, and the tight cephalopelvic fit. The main consequence is the high mortality due to cephalopelvic disproportion today. In the next part of this work, we will adress two questions: 1) Is the difference in body size between male and female due to a difference in the growth process? 2) Does adaptive allometric solution protect the birth canal size in a small-bodied population?

3 Sexual dimorphism and bimaturism from the primate perspective

3.1 Sexual dimorphism in primates

Sexual dimorphism in primates has been investigated with different variables or index. Height and weight are the mean variables because they are simple and reflected the overall size/volum of the body. Anatomical specificities, such as the presence of a tail, make several indexes (*e.g.* ratio of distance from the vertex to most distal part of the tail between males and females) unrelevant for the comparison of sexual dimorphism among primates. Wood and Chamberlain (1986) analyse the relationship between body size and pelvic dimorphism in several species of primates including modern man. In this study, femoral length is used as a proxy of body height, and a sexual dimorphism index is calculated (female femoral length/male femoral length X100). This index is always smaller than 100%, indicating that females are always smaller than females in these primates. But sexual dimorphism index could be calculated with different variables such as body weight or trunk length. The table 1 shows these sexual dimorphism indexes from different studies. In a study of the sexual dimorphism of the cercopithecines in northeast of Gabon, the sexual dimorphism index, based on the trunk length, is always smaller than 100% (Gautier-Hion, 1975). Hamada *et al.* (1996) found that the mean adult weight is 53,2 kg for males, and 42,7 kg for females in chimpanzees. These findings are close to those from the Yerkes chimpanzees (Gavan, 1971) and give a dimorphism index, based on body weight, of 80%. Among primates, male body size is greater than female body size. This rule seems to be common in this order.

Difference in size between male and female occurs during the growth process. In primates, difference in growth process between male and female explains the sexual dimorphism in adult body size. For example, Hamada *et al.* (1996) show that in chimpanzees, males have two peaks of velocity growth during the juvenile stage when females have only one peak. The marked difference is the magnitude of the peak velocity between males (5,91 kg/yr) and females (4,8 kg/yr). For Leigh and Shea (1995), sex difference in rate growth primaly account for dimorphism in chimpanzees. For Shea (1985), in common and pygmy chimpanzees, females are bigger than males at the dental stage 4 (c.a. 6 yr) for both cranial and postcranial dimensions. The female growth spurt occurs at the dental stage 4 in chimpanzees, and 3 in gorillas, and may be related to the development of the reproductive system (Harcourt *et al.* 1980). Finally, at the end of the growth process, the asymptotic body mass is greater in male compared to female in chimpanzees and gorillas. Two major differences could explain the sexual dimorphism in asymptotic body mass: a difference in the duration of the growth process (e.g. males have a prolonged growth period and reach a bigger size) or a difference in the growth rate (males grow faster than females in the same period of the growth process). This combination of differences in duration and rate is the major explanation of sex difference in asymptotic body size in primates (Leigh & Terranova, 1998).

3.2 Mechanisms of sexual dimorphism humans and primates

In humans, difference in body size is already present at birth, where males are 90g heavier than females (Janssen *et al.*, 2007). Compared to non-human primates, humans show specific patterns of the growth process. They have a slow growth rate during the 4-8 years, corresponding to the childhood period: humans have a stage of infancy which is absent in others primates (Bogin, 1997). But humans and non-human primates share a common pattern which is the bimaturism. Bimaturism is the difference in the duration of the growth process

between male and female (Leigh & Terranova, 1998). The spurt in growth rate at adolescence begins earlier in females than in males. Indeed, at the beginning of adolescence, females are generally larger than males. At twelve years old, mean body weight of females is 37 kg (+/- 4kg) and males body weight is 35 kg (+/- 4kg) (Sempé et al., 1979). Fig. 1 shows the growth of body height in a sample of males and females. Data are from a French longitudinal cohort study based on 588 boys and girls from 1954-1955 to 1974-1975. Inclusion criteria were: absence of congenital abnormalities and a birthweight between 2.5 and 4.7 kg (Sempé et al., 1979). The fig.1 shows that males exhibit a peak of growth rate at twelve year-old while females start to decrease their growth rate until the asymptotic body size is reached, at *ca*. 15 years old. In consequence, the arrest of growth occurs earlier in females than in males which are still growing up after 15 years old. This illustrates the bimaturism and is mainly explains by different level of hormonal secretion throughout adolesence. In primate, the serum hormone level plays a crucial role in the growth process. In the chimpanzee male the concentration of testosterone before 6 years of age averages 13 ng/dl whereas this concentration increases up to 400 ng/dl during the puberty (Martin *et al.*, 1977). In human, the serum testosterone concentration averages 9 ng/dl before 12 years and 340 ng/dl at 14 years (Winter, 1978). Testosterone increases muscles size and the proportion of type II fibers (Bhasin *et al.* 1996). While testosterone plays a major role in the growth process aspecially in male, it is well-known that females exhibit a close correlation between the menarcheal age and the asymptotic body size (Simmons & Greulich, 1943), suggesting a strong correlation between the reproductive capacity and skeletal maturation. Menarche is related to the maturation of the hypothalamus and the secretation of hormones such as the oestrogen. This hormone is involved in epiphyseal fusion and could play a key role in the regulation of growth (Simm *et al.*, 2008).

3.3 Factors against bimaturism in primates

Among primates, the level of sexual body size dimorphism could be different. This difference could be explained by factors acting against bimaturism. Seasonality and food access may contribute to the limitation of the duration of growth process. Indeed, seasonality may select animals that are able to reach a certain size and level of foraging competence before a stressfull season. This ecological risk may select short period of growth. This potential risk could explain low level of bimaturism and low level of sexual body size dimorphism in lemurids (Leigh & Terranova, 1998). However, for the anthropoid primates, the exposition to the same risk (seasonality) would produce slow growth rate over prolonged period (Janson & van Schaik, 1993). Slowing growth rate would represent a strategy that alleviates the energetic demand during stressfull period. Reproductive success could be another important factor that would reduce the prolonged growth period in male and thus bimaturism. Males that exhibit a longer period of maturation are at risk of missing reproductive seasons during early adulthood. This reason would be another explanation, with seasonality, to the low level of bimaturism in lemurids (Leigh & Terranova, 1998). In human, bimaturism also explains sexual body size dimorphism. The level of sexual dimorphism is moderate in comparison with other primates such as gorillas (Table 1). This moderate level of sexual dimorphism and bimaturism could correspond with the moderate amount of polygeny in our species (Weisfield & Berger, 1983). environnemental factors would also influence the growth process, and a recent study found that immune function plays a crucial role on growth (Urlacher *et al.*, 2017).

NCWS hypothesis suggests that food deprivation explains the difference in body size between male and female. If this hypothesis is true, this nutritional factor would affect body size only if food limitation occurs during the growth process, not after when the adult size is reached. However, ethnological studies show that societies where inequalities in food distribition between male and female exist, girls and boys are considered with the same status (subadult) and are equal in regard to the food distribution (Marlowe, 2010; Atse & Adon, 2015). In the primate context, asymptotic body size difference is mainly explained by bimaturism, a pattern of the growth process shared by anthropoid primates and humans. The limitation to the food access (seasonal stress) could potentially change pattern of growth process, but this would not change body size sexual dimorphism since primates, such as lemurids, could follow an alternative adaptation involving an increase of growth rate instead of a prolonged duration (Leigh & Terranova, 1998). In humans, the difference in growth process between males and females is mostly explained by hormonal differences rather than nutritional differences.

NCWS hypothesis assums that body size difference between male and female has implications for obstetrics and prevents the ability to give birth successfully. Indeed, pelvic size is supposed to become smaller while the maternal stature decreases as if pelvic size was scaled to the body size of the mother (Touraille, 2008). A major consequence would be the high rate of cephalo-pelvic disproportion, approximately 8%, in humans (Maharaj, 2010). In this hypothesis, the role of the pelvic morphology is not considered. Is there an adaptation of

pelvic morphology for the birthing function in small-statured women? What are the different patterns of human birth, and how are they explained in an evolutionary perspective?

4 Birth process in humans

4.1 Human birth patterns

Human birth is supposed to be unique among primates in many aspects (Rosenberg &Trevathan, 2002). The uniqueness of human childbirth relies on its complexity (*i.e.* birth is a lenghty and painful event) and difficulty (*i.e.* birth could be dystocic). However, recent evidences suggest that some characteristics of the birthing process are comparable between human and non-human primates (Pan *et al.*, 2014; Kawada *et al.*, 2020). NCWS hypothesis supports that the high rate of cephalo-pelvic disproportion, typical of humans, has a cultural explanation and could be due to food deprivation. However, several non-human primate species such as squirrel monkeys, exhibit a tigh cephalopelvic fit and high neonatal mortality, from 13% to 35% (Coates et al., 1995). These would suggest that among primates, the high frequency of labor dystocia is not unique to humans. Kawada et al. (2020) found that rhesus macaques exhibit a tight cephalo-pelvic fit as humans do (Frémondière et al., 2021). In our specie, what makes our birth special is the way the fetus negociates the convoluted shape of the birth canal. The typical movement of the fetal head is called birth mechanism (Frémondière et al., 2017). This birth mechanism is explained by the shape of the birth canal. This canal is divided in three planes: the inlet, midplane and outlet. Inlet is the upper part of the canal, and is transversally elongated, while the midplane and outlet (lower part of the canal) are sagittaly elongated. While the fetal head oriented itself in the most spacious space of each pelvic plane, a movement of rotation occurs as the presenting part passes from the inlet to the midplane. This movement requires the flexion of the head. Then, it follows a curved trajectory that passes in front of the ischial tuberosities. Therefore, human birth is said to be “ante-ischiatic” and it necessitates a birth attendant given the dominante occiput anterior position (Rosenberg & Trevathan, 2002). The human pattern of “obligate midewifery” or “obligate birth-attendant” would have deep consequences for the emergence of culturally specific rules and ritual behaviors associated with childbirth (Rosenberg & Trevathan, 2002).

4.2 Birth process in extant human and sexual dimorphism

The shape of the birth canal plays a crucial role in the delivery outcomes. Birth is eutocic when birth canal shows a transversally large inlet (Fremondiere *et al.*, 2017), a sagittaly (Harper *et al.*, 2013) and transversally elongated midplane, and a wide sub-pubic angle (Fremondiere *et al.*, 2017). These patterns are related to sexual dimorphism. For instance, female pelvises have wide sub-pubic angle and transversally large inlet compared to male pelvises (Cadwell and Moloy, 1938). Among other dimorphic traits, the greater sciatic notch is more open in females than in males (Bruzek, 2002). This trait could be explained by the curved shape of the birth canal which contributes to the “ante-ischiatic” birth. These patterns of the birth canal (wide sub-pubic angle, transversally elongated inlet, wide greater sciatic notch) are related to the birth mechanism (rotational birth, ante-ischiatic birth). Even if the birth canal is larger than the true pelvis of males (Tague, 2000), its morphological patterns explain the complexity of the human birth. NCWS hypothesis posits that birth canal morphology is not adapted to the parturition (Touraille, 2005) but the patterns of sexual dimorphism contradict this suggestion. Moreover, a recent study shows evidences of developmental adaptation of the human female pelvis to the obstetric constraints (Huseynov et al., 2016). According to these findings, female pelvis would exhibit developmental patterns resulting in the expansion of obstetric relevant dimensions during the age of maximum fertility (25-30 years old). However, the findings of a recent study show that pelvic shape variation is explained by neutral population history rather than obstetrical constraints (Betti & Manica, 2018). In this study, the geographical distance from Africa is used as a proxy of the neutral population history. When climate is considered as a factor of explanation of pelvic shape variability, its effect occurs differently on male and female: a significant correlation exists between climate and shape variability of male pelvises, but not female pelvises. For these authors, this difference is explained by the effect of obstetrical constraints (Betti & Manica, 2018). Given the role of the parturition in the shape of the birth canal, small-bodied women are supposed to have well-adapted pelvises since they are under intense influence of obstetrics selection.

4.2 Body size dimorphism and pelvic dimorphism

According to the NCWS hypothesis, the consequence of the gender system is the reduction of the global size of the birth canal, which leads to the emergence of birth difficulties. For Touraille (2008), this oppression of males on females leads to the “pain and waste of life”. But in this hypothesis, adaption of small pelvises to the

obstetrical demand is not considered. NCWS hypothesis suggests that the major constraint of the reduction of the pelvis size is the body weight in the bipedal context (Touraille, 2008). Small-bodied women would be more lightweight and would exhibit a less reduced pelvic size. However, Fischer and Mitteroecker (2015) investigate this specific adaptation of small female pelvises. They found that small pelvic inlet is more rounded, which is more obstetrically efficient. For Kurki (2007), body size dimorphism and pelvic dimorphism are not related. Differences between short and tall females are not significant for the posterior spaces of the three pelvic planes. Moreover, small females have a longer sagittal outlet than tall females (Kurki, 2007, but see Kurki & Decrausaz 2016). The adaptation of the inlet shape is crucial for the success of parturition since the inlet is a bony ring where the effect of pelvic relaxation is minimal (Frémondière et al., 2021). Moreover, a sagittaly elongated outlet is important during the expulsion stage since it facilites the "ante-ischiatic" and "occiput anterior" birth. Birth canal of short female is therefore well-adapted to the parturition. The specific examination of the pelvic traits at the birth canal shows that the body size and birth canal size are not correlated (Kurki, 2007; Fischer and Mitteroecker, 2015). The decreasing size of female may be not correlated to obstetrical difficulties as suggested by the NCWS hypothesis and the pelvic shape of small women is also well-adapted to the parturition.

4.3 The obstetric dilemma, an alternative explanation to the emergence of the food sharing

In the NCWS hypothesis, "food sharing" behavior plays a crucial role in the explanation of sexual body size dimorphism. An alternative hypothesis suggests that "food sharing" appears during human evolution though the emergence of secondary alriciality (Spikins, 2019). According to this, complex relationships and intensive social behavior appear during human evolution with the acquisition of a specific neuro-develepmental phase in infant life. Such a complex relationships and intensive social behavior are in accordance with the "obligate midewifery" pattern which makes the birth process a social event (Rosenberg & Trevathan, 2002). Portmann (1941) suggested that human embryonic development lasts 21 months and is divided into two periods: intrauterine (9 months) and extrauterine (12 months). As a result, the human neonate retains fetal patterns of brain growth when delivered, and benefits of the life outside the mother to acquire important cognitive and behavioral functions ("extra uterine spring" hypothesis).

Fig. 2 shows the mean differences between the obstetric dilemma hypothesis (ODH) and the NCWS hypothesis. According to this hypothesis, Male-male competition selects males with aggressive behavior and this generates sexual inequality in the access to food (a primate initial condition), Inequality in the access to food is promoted through the emergence of the gender system. This difference in the access to food leads to the general reduction of the size of the birth canal. Such a reduction increases the cephalo-pelvic mismatch between the pelvis and the neonate, which leads to the increasing risk of fetal-pelvic disproportion and obstetrical difficulties (Maharaj, 2010). Moreover, the inequality in the access to food explains the dimorphism in body size between men and women. Alternatively, the obstetric dilemma hypothesis supposes that the acquisition of bipedal locomotion, and the increasing size of the neonatal head promote the emergence of a complex way to give birth (obstetric mechanism and difficulties during childbirth). Contrary to the NCWS hypothesis, ODH does not assum that locomotion reduces the size of the birth canal, but increases the complexity of the shape of the birth canal (this canal is curved in modern human but straight in non-human primate) which explains the birth complexity and difficulties today. Bipedalism and erected posture are supposed to deeply reshape the birth canal with the shortening of the distance between the sacro-iliac joint and acetabulum (Straus, 1929; Berge, 1984) while increasing size of the adult cranium during human evolution (*i.e.* encephalization process) is correlated with the increasing size of the neonate heads (DeSilva and Lesnik, 2008). The ODH assums that secondary altriciality originates from these two opposing forces (encephalization vs bipedalism) (Washburn, 1960). An alternative hypothesis, the energetic for gestation and growth hypothesis (EGG hypothesis) assums that the timing of parturition is constrained by the metabolic limitation of the mother instead of pelvic size (Dunsworth et al., 2012). EGG and ODH hypotheses are not mutually exclusive in this context. These hypotheses suggest a limitation to the increasing size of the neonate and the emergence of 2nd altriciality. Contrary to the NCWS hypothesis, we propose that the sexual dimophism in body size is an initial primate condition, and is not generated by the inequality in the access to food. If food is inequaly distributed between men and women, this cultural practice should originate from the complex social organizations that appears during mesolithic/neolithic transition (sedentary societies, emergence of leadership) (Knauft, 1991). The emergence of high social tensions during this transition would have generated inequalities between males and females in many aspects, including in food sharing.

5 Conclusion

Human sexual dimorphism must be considered in the primate context. Humans follow the general rule of the primate order where males are bigger than females. Human sexual dimorphism is not outside the primate range and some non-human primates show a bigger sexual dimorphism (*e.g. Gorilla, Cercopithecus*) than humans. The origin of sexual dimorphism lies on the sexual difference in the growth process. While food intake provides the energy to sustain growth, this process has a strong biological background. Its mechanism implies hormone level, sexual bimaturism and sexual differences already present at birth. Considering female food privation has the only source of explanation of sexual dimorphism seems unlikely. If female food privation is a part of the explanation of sexual dimorphism, it nonetheless has negligible consequences during the birth process, because small women show a specific adaptation of their birth canal shape to insure a successful birth. We suggest that inequity in food distribution between male and female is a recent phenomenon in human evolution, resulting from the emergence of large scaled-societies with high social tension. Complex birth process in extant humans may be explained by the tight fit between female pelvis and fetus size. The presence of this cephalo-pelvic tight fit would be more likely explained by mechanical (ODH) or energetic constraints (EGG), rather than the indirect consequence of the reduction of the female body size (NCWS).

Declaration

Competing Interests The authors declare no competing interests.

References

Armit, I. (2010). Violence and society in the deep human past. *British journal of criminology*. *51*(3), 1-19

Atse, A.A.P., & Adon, KP. (2015). « Let me Eat your Meat ».The Sharing of Animal Proteins in Akyé Culture. *Journal des Anthropologues*, 140-141, 193-212.

Baniel, A., Cowlishaw, G., & Huchard, E. (2017). Male Violence and Sexual Intimidation in a Wild Primate Society. *Current biology*. (27)14, 2163 - 2168

Bhasin, S., Storer, T. W., Berman, N., Callegari, C., Clevenger, B., Phillips, J., Bunnell, T. J., Tricker, R., Shirazi, A. & Casaburi, R. (1996). The effects of supraphysiologic doses of testosterone on muscle size and strength in normal men. *New England Journal of Medicine*, 335, 1–7.

Berge, C., Orban-Segebarth, R., & Schmid, P. (1984). Obstetrical interpretation of the australopithecine pelvic cavity. *Journal of Human Evolution*, *13*(7), 573-587.

Betti, L. & Manica, A. (2018). Human variation in the shape of the birth canal is significant and geographically structured. *Proceedings of the Royal Society B, 285*(1889), *1-9.*

Bogin, B. (1997). Evolutionary hypotheses for human childhood. *Yearbook of physical anthropology, 40*, 63-89.

Bruzek, J. (2002). A method for visual determination of sex, using the human hip bone. *American journal of physical anthropology*, *117*(2),157–168.

Caldwell, W.E. & Moloy, H.C. (1938). Anatomical variation in the female pelvis: their classification and obstetrical significance. *Proceedings of the Royal Society of medicine, 32, 1-30.*

Campbell, A. (2012). The evolutionary psychology of women's aggression. *Philosophical transactions of the Royal Society of London B, 368*(1631), *1-11.*

Coates, K. W., Gibson, S., Williams, L. E., Brady, A., Abee, C. R., Shull, B. L., & Kuehl, T. J. (1995). The squirrel monkey as an animal model of pelvic relaxation: An evaluation of a large breeding colony. *American Journal of Obstetrics and Gynecology, 173*(6), 1664–1670.

Danese, A., & Widom, C.S. (2020). Objective and subjective experiences of child maltreatment and their relationships with psychopathology. *Nature human behaviour*, 4, 811–818.

Dawson-Hughes, B. (2003). Interaction of Dietary Calcium and Protein in Bone Health in Humans. *The journal of nutrition,133*(3), *852-854.*

DeSilva, J. M., & Lesnik, J.J. (2008). Brain size at birth throughout human evolution: A new method for estimating neonatal brain size in hominins. *Journal of Human Evolution, 55*(6), 1064-1074.

Dunsworth, H. M., Warrener, A. G., Deacon, T., Ellison, P. T., & Pontzer, H. (2012). Metabolic hypothesis for human altriciality. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(38), 15212–15216.

Fischer, B. & Mitteroecker, P. (2015). Covariation between human pelvis shape, stature, and head size alleviates the obstetric dilemma. *Proceedings of the National Academy of Sciences USA, 112*(18), *5655–5660.*

Flack, J. C. and de Waal, F. B. M. (2004). Dominance style, social power, and conflict management in macaque societies: A conceptual framework. In Thierry, B., Singh, M., & Kaumanns, W. (Eds). *Macaque societies: a model for the study of social organization.* (pp.157–181). Cambridge University Press.

Fournier, T., Jarty, J., Lapeyre, N. & Touraille, P. (2015). L'alimentation, arme du genre. *Journal des anthropologues, 140-141, 19-49.*

Frémondière, P., Thollon, L., Adalian, P., Delotte, J. & Marchal, F. (2017). Which Foetal-Pelvic variables are useful for predicting caesarean section and instrumental assistance? *Medical Principle and Practice, 26*(4), 359-367.

Frémondière, P., Thollon, L., & Marchal, F. (2017). The emergence of obstetrical mechanism: From Lucy to *Homo sapiens*. *Gynécologie Obstétrique Fertilité & Sénologie*, *45*(3), 164–171.

Frémondière, P., Thollon, L., & Marchal, F. (2021). Pelvic and neonatal size correlations in light of evolutionary hypotheses. *American journal of human biology*, e23619, doi: 10.1002/ajhb.23619.

García-Moreno, C., Jansen, H.A.F.M., Ellsber, M., Heise, L. & Watts, C. (2005). WHO multi-country study on women's health and domestic violence against women. World Health Organization, Geneva.

Gautier-Hion, A. (1975). Dimorphisme sexuel et organisation sociale chez les Cercopithécinés forestiers africains. *Mammalia, 19*(3), 365-374.

Gavan, J. A. (1953). Growth and development of the chimpanzee: a longitudinal and comparative study. *Human biology, 25, 93-143.*

Gavan, J. A. (1971). Longitudinal, postnatal growth in chimpanzee. In G.E. Bourne (ed.), *The chimpanzee* (pp.46-102). Basel, Switzland: Karger.

Goetz A, (2010). The evolutionary psychology of violence. *Psicothema, 22*(1), 15-21

Hamada, Y., Udono, T., Teramoto, M. & Sugawara, T. (1996). The growth pattern of chimpanzees: somatic growth and reproductive maturation in *Pan troglodytes*. *Primates, 37, 279-295.*

Harcourt, A. H., Fossey, D., Stewart, K. J. & Watts, D. P. (1980). Reproduction in wild gorillas and some comparisons with chimpanzees. *Journal of reproduction fertility (suppl), 28, 59-60.*

Harper, L. M., Odibo, A. O., Stamilio, D.M. & Macones, G.A. (2013). Radiographic measures of the mid pelvis to predict cesarean delivery. *American Journal of Obstetrics and Gynecology, 208, 1–6.*

Heise, L.L., Ellsberg, M. & Gottemoeller, M. (1999). Ending violence against women (population reports, series L, no 11). Baltimore: Johns Hopkins University School of Public Health, Center for Communications Programs.

Huseynov, A., Zollikofer, C.P.E., Coudyzer, W., Gascho, D., Kellenberger, C., Hinzpeter, R., , & Ponce de León, M.S. (2016). Developmental evidence for obstetric adaptation of the human female pelvis. *Proceedings of the national academy of sciences of the united states of america*. *113*(19), 5227-5232.

Janson, C. H., & van Schaik, C. P. (1993). Ecological risk aversion in juvenile primates: slow and steady wins the race. In Pereira, M. E., & Fairbanks, L. A. (eds.), *Juvenile Primates*. (pp. 57-76). Oxford, UK, Oxford University Press.

Janssen, P.A., Thiessen, P., Klein, M.C., Whitfield, M.F., MacNab, Y.C. & Cullis-Kuhl, SC. (2007). Standards for the measurement of birth weight, length and head circumference at term in neonates of European, Chinese and South Asian ancestry. *Open Medicine, 1, 74-88*.

Jolly, A. (1984). The puzzle of female feeding priority. In M. Small (ed.), *Female primates: studies by women primatologists* (pp. 197-215). New York, USA: Allan R Liss.

Kawada, M., Nakatsukasa, M., Nishimura, T., Kaneko, A., & Morimoto, N. (2020). Covariation of fetal skull and maternal pelvis during the perinatal period in rhesus macaques and evolution of childbirth in primates. *Proceedings of the national academy of sciences of the united states of america*, *117*(35), 21251–21257.

Knauft, B.M. (1991). Violence and Sociality in Human evolution. *Current Anthropology, 32*(4), 391-428.

Kurki, H. K. (2007). Protection of Obstetric Dimensions in a Small-Bodied Human Sample. *American Journal of Physical Anthropology, 133*(4), 1152-1165.

Kurki, H. K., & Decrausaz, S. L. (2016). Shape variation in the human pelvis and limb skeleton: Implications for obstetric adaptation. *American journal of physical anthropology*, *159*(4), 630–638.

Leigh, S. R. & Shea, B. R. (1995). Ontogeny and the evolution of adult body size dimorphism in apes. *American Journal of Primatology, 36*(1), 37-60.

Leigh, S.R. & Terranova C.J. (1998). Comparative perspectives on bimaturism, ontogeny, and dimorphism in lemurid primates. *International journal of primatology,* 19, 723-749.

Maharaj, D. (2010). Assessing cephalopelvic disproportion: back to the basics. *Obstetrical and gynecological survey*, *65*(6), 387-395.

Marlowe, F. (2010). *The Hadza: hunter-gatherers of Tanzania*. California: University of California Press.

Martin, D. L., Harrod, R.P., & Fields, M. (2010). Beaten down and worked to the bone: bioarchaeological investigations of women and violence in the ancient southwest. *Landscapes of violence*, *1*(1), 1-19.

Martin, D. E., Swenson, R. B. & Colins, D.C. (1977). Correlation of serum testosterone levels with age in male chimpanzees. *Steroids, 29*(4), 471–481.

McHenry, H. M. (1992). Body size and proportions in early hominids. American Journal of Physical Anthropology. *87,407–431*.

Meyer, H. E., Pedersen, J. I., Loken, E. B. & Tverdal, A. (1997). Dietary factors and the incidence of hip fracture in middle-aged Norwegians. A prospective study. *American Journal of Epidemiology, 145*(2), 117–123.

Muller, M.N., Kahlenberg, S.M., Thompson, M.E., & Wrangham R.W. (2007). Male coercion and the costs of promiscuous mating in chimpanzees. Proceedings of the Royal Society B, 274(1612), 1009-1014.

Nanda, S. (1998) *Neither Man Nor Woman: The Hijras of India*. South Africa: Wadsworth Publishing.

Pan W, Gu., T, Pan., Feng, Y.C., Long, Y., Zhao, Y., Meng, H., Liang, Z., & Yao,M., (2014). Birth intervention and non-maternal infant-handling during parturition in a nonhuman primate. *Primates*, 55, 483-488.

Plavcan, J. M. & van Schaik, C. P. (1997). Interpreting hominid behavior on the basis of sexual dimorphism. *Journal of human evolution, 32*(4), 345–374.

Peters, J., Shackelford, T.K. & Buss, D.M. (2002). Understanding domestic violence against women: using evolutionary psychology to extend the feminist functional analysis. *Violence and victims, 17*(2), 255-264.

Portmann, A. (1941). Die Tragzeiten der Primaten und die Dauer der Schwangerschaft beim Menschen: Ein Problem der vergleichenden Biologie. *Revue Suisse de Zoologie, 48*, 511–518.

Raymond, M., Pontier, D., Dufour, A.B., & Møller, A.P. (1996). Frequency-dependent maintenance of left handedness in humans. *Proceedings of the Royal Society B, 263*(1377), 1627-1633.

Richards, A. I. (1932) *Hunger and Work in a Savage Tribe. A Functional Study of Nutrition among the Southern Bantu*. Londres: Routledge.

Ridgeway, C.L. & Correll, S.J. (2004). Unpacking the gender system a theoretical perspective on gender beliefs and social relations. *Gender and society*, *18*(4), 510-531.

Rosenberg, K., & Trevathan, W. (2002). Birth, obstetrics and human evolution. *BJOG: An International Journal of Obstetrics and Gynaecology, 109*(11), 1199–1206.

Schechter, S. (1982). *Women and male violence: the visions and struggles of the battered women's movement*. Cambridge: South End Press.

Schurch, M. A., Rizzoli, R., Slosman, D., Vadas, L., Vergnaud, P. & Bonjour, J. P. (1998). Protein supplements increase serum insulin-like growth factor-I levels and attenuate proximal femur bone loss in patients with recent hip fracture. A randomized double-blind, placebo-controlled trial. *Annals of internal medicine*, *128*(10), 801–809.

Sempé, M., Pédron, G. & Roy-Pernot, M. P. (1979). *Auxologie méthode et séquences.* Paris: Théraplix.

Sentell, C. J. (2015). *Freedom and food, slavery and agriculture: a philosophical ecology*, PhD thesis, Graduate School of Vanderbilt University, Nashville, 351 p.

Shea, B.T. (1981). Relative growth of the limbs and trunk in the African apes. *American Journal of physical anthropology, 56*(2), 179-201.

Shea, B.T. (1985). The ontogeny of sexual dimorphism in the african apes. *American journal of primatology, 8*(2), 183-188.

Simm, P. J., Bajpai, A., Russo, V. C., Werther, G. A. (2008). Estrogens and growth. *Pediatric Endocrinology Reviews, 6*(1), 32-41.

Simmons, K., & Greulich, W. (1943). Menarcheal age and the height, weight and skeletal age of girls aged 7 to 17 years. *The journal of pediatrics, 22*(5), 518- 548

Smith, A. H., Butler, T.M. & Pace, N. (1975). Weight growth of colony-reared chimpanzees. *Folia Primatologia, 24*(1), 29-59.

Smuts, B.B., & Smuts, R.R. (1993). Male aggression and sexual coercion of females in Nonhuman Primates and other mammals : evidence and theoretical implications. *Advances in the study of behavior*. 22, 1-63.

Spikins, P. (2019). Sharing and inclusion: generosity, trust and response to vulnerability in the distant past. In N, Lavi., & D. Friesem. (Eds.) *Towards a Broader View of Hunter-Gatherer Sharing*. (pp. 57-70). Cambridge.

Straus, W.L. (1929). Studies on primate ilia. *American Journal of Anatomy, 43*(3), 403-460.

Tague, R. (2000). Do big females have big pelves? *American journal of physical anthropology, 112*(3), 377–393.

Touraille, P. (2005). *Dimorphismes sexuels de taille corporelle : des adaptations meurtrières ? : les modèles de la biologie évolutive et les silences de l'écologie comportementale humaine*. PhD thesis, Ecole de Hautes Etudes en Sciences Sociales, Paris, 441 p.

Touraille, P. (2008). *Hommes grands, femmes petites: une évolution coûteuse. Les régimes de genre comme force sélective de l'évolution biologique*. Paris: Éditions de la Maison des Sciences de l'Homme.

Touraille, P. (2013). Human Sex Differences in Height: Evolution due to Gender Hierarchy ? In Ah-Kink, M. (Ed.), *Challenging popular myths of sex, gender and biology*. (pp. 65-75). Uppsala, Sweden: Springer.

Tung, A. T. (2012). Violence against women: differential treatment of local and foreign females in the heartland of the Wari empire, Peru. In Martin, D.L & Harrod, R. P. (eds.), *The Bioarchaeology of Violence.* (pp. 182-198) Florida, USA: University Press of Florida.

Urlacher, S.S., Ellison, P.T., Sugiyama, L.S., Pontzer, H., Eick, G., Liebert, M.A., Cepon-Robins, T.J., Gildner, T.E., Snodgrass, J.J., (2017). Tradeoffs between immune function and childhood growth among Amazonian

forager-horticulturalists. *Proceedings of the National Academy of Sciences of the United States of America*, 115 (17), 3914–3921.

Washburn, SL. (1960). Tools and human evolution. *Scientific American, 203,* 63–75.

Weisfeld, G.E., & Berger, J.M. (1983). Some features of human adolescence viewed in evolutionary perspective. *Human Development, 26*(3), 121-133.

Wilson, M. & Daly, M. (1993). An evolutionary psychological perspective on male sexual proprietariness and violence against wives. *Violence and Victims, 8*(3), 271-294.

Winter, J. S. D. (1978). Prepubertal and pubertal endocrinology. In F. Falkner & J.M. Tanner (eds.), *Human Growth, vol. 2, Postnatal Growth*. (pp. 183–213). New York, USA: Plenum.

Wolfe, L. D., & Gray, P. J. (1982). A cross-cultural investigation into the sexual dimorphism of stature. In R. L. Hall (Ed.), Sexual dimorphism in Homo sapiens. A question of size . New York: Praeger.

Wolpoff, M. H. (1976). Some aspects of the evolution of early hominid sexual dimorphism. *Current Anthropology, 17*(4), 579–606.

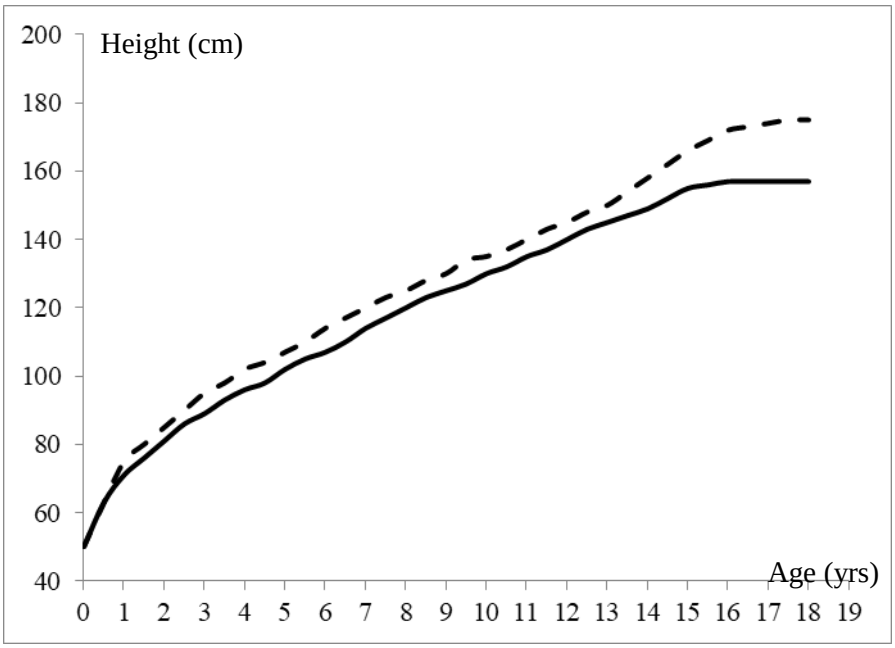
Wood, B.A. & Chamberlain, A. T. (1986). The primate pelvis: allometry or sexual dimorphism. *Journal of Human Evolution, 15*(4), 257-263.

World Health Organization (2014). Global status report on violence prevention 2014.

Wright, E., Galbany, J., McFarlin S.C., Ndayishimiye, E., Stoinski, T.S., Robbins, M.M. (2019). Male body size, dominance rank and strategic use of aggression in a group-living mammal. *Animal Behaviour*, 151, 87-102.

Zwi, A (1982). Towards an epidemiology of political violence in the third world. *Social science & medicine, 28*(7),633 – 642.

Fig 1. Growth of body size in male and female



Dotted line represents boy's growth, continued line represents girl's growth. Data are from a French cohort study based on 588 boys and girls borned between 1954-1955 (Sempé *et al.*, 1979).

Fig 2. Nutritional Constraints on Women's Size Selection Hypothesis versus Obstretric Dilemma Hypothesis for the explanation of sexual body size dimorphism and birth patterns in extant humans.

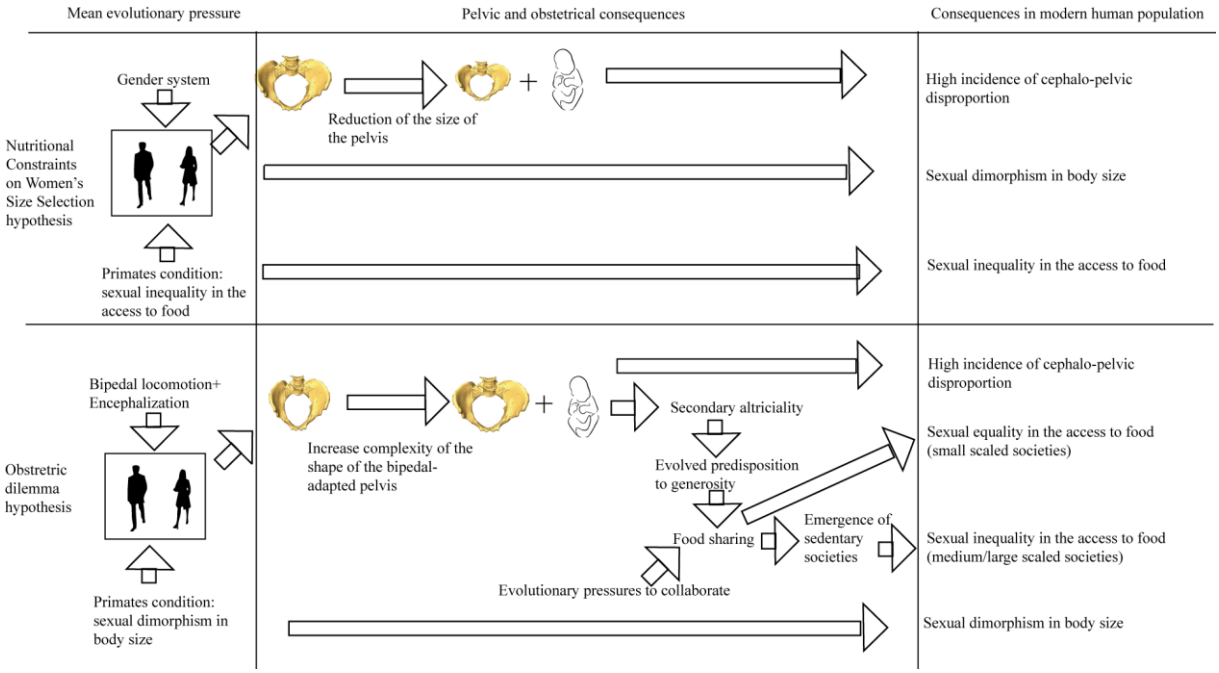


Table 1 : Body size dimorphism in primates

Primates species	Sexual dimorphism index	Variable	References
Presbytis spp.	95	femoral length	Wood and Chamberlain, 1986
Cercopithecus spp.	84	femoral length	Wood and Chamberlain, 1986
Colobus spp.	96	femoral length	Wood and Chamberlain, 1986
Homo spp.	92	femoral length	Wood and Chamberlain, 1986
Pan spp.	94	femoral length	Wood and Chamberlain, 1986
Papio spp.	88	femoral length	Wood and Chamberlain, 1986
Gorilla spp.	83	femoral length	Wood and Chamberlain, 1986
Miopithecus talapoin	90	trunk length	Gautier-Hion, 1975
Cercopithecus cephus	87	trunk length	Gautier-Hion, 1975
Cercopithecus nictitans	81	trunk length	Gautier-Hion, 1975
Cercopithecus pogonias	83	trunk length	Gautier-Hion, 1975
Cercopithecus neglectus	77	trunk length	Gautier-Hion, 1975
Lophocebus albigena	90	trunk length	Gautier-Hion, 1975
Cercocebus galeritus	79	trunk length	Gautier-Hion, 1975
Pan troglodytes	80	body weight	Hamada, 1996
Pan troglodytes	89	body weight	Gavan, 1953
Pan troglodytes	90	body weight	Smith *et al.*, 1975
Pan troglodytes	98	femoral length	Shea, 1981
Gorilla gorilla	83	femoral length	Shea, 1981