Controversy Regarding the Obstetric Dilemma

by Dana Macfarlane

The evolution of human pelvic morphology has been extensively researched for several decades, with most studies referring back to an article published almost sixty years ago. In 1960, S. L. Washburn proposed the obstetric dilemma (OD) hypothesis in order to describe the evolution of the human pelvis. The hypothesis proposes that stabilizing selection of the human female pelvic morphology results from the conflicting demands of bipedal locomotion and the birth of large-headed neonates (Fischer & Mitteroecker, 2015). Thus, while a narrow pelvis would optimize bipedal locomotion, a wide pelvis would accommodate large-headed neonates. Washburn (1960) thus suggested the dilemma between the two opposing factors would be ameliorated by stabilizing selection, allowing for both bipedalism and large-headed neonates. However, recent research suggests that the obstetric dilemma hypothesis is incorrect or is insufficient for the complex description of the selective pressures acting on the pelvis throughout the evolution of hominids. Some even propose that there is actually very little sexual dimorphism of the human pelvis (Beti et al., 2013; Gruss & Schmitt, 2015). The question, therefore, becomes: is there sexual dimorphism in the human pelvis and, if so, why? The disagreements are important to review because they indicate that factors like variability and environmental effects may be able to provide greater insight into the evolution of humankind.

The obstetric dilemma was developed in order to describe the evolution of the human pelvis as it pertains to childbearing and not only makes a hypothesis, but also predicts aspects impacted by the dilemma such as pelvis size. The aforementioned two opposing forces—a narrow pelvis to optimize bipedal locomotion and a wide pelvis to accommodate large-headed neonates—thus create a stable morphology for the female pelvis, which would lead one to predict less variability amongst female pelvises than that of males (Gruss & Schmitt, 2015). While the obstetric pressure is derived from large-headed babies, selecting for wide canals, the bipedal locomotion pressure would select for a narrower pelvis in this instance, as the OD claims a wider and more feminine pelvis has higher locomotor costs (Fischer & Mitteroecker, 2015; Washburn, 1960). Additionally, the OD proposes that the size of the fetal brain is restricted by the locomotor pressures acting on the pelvis. This means that the stabilizing selection predicted by the OD prevents the pelvic canal from becoming larger because this would compromise locomotor needs (Dunsworth et al., 2012). The dilemma is also not unique to humans, as other small-bodied primates like macaques have a tight fit in the birth canal and have rotation during birth (Trevathan, 2015). The obstetrics for this hypothesis deal only with parturition and the set up for birth and do not comment on other aspects such as metabolism or proportions.

Testing of the OD hypothesis has been done on the biomechanics of pelvic morphology in humans in order to assess whether locomotor costs are as great as the hypothesis implies. The consequence of dissimilar pelvic morphologies on bipedal locomotor costs can be explored by focusing on the hip abductor muscles (gluteus minimus and gluteus medius) and the force activation of these muscles (Warrener et al., 2015). These muscles can be tested by having participants walk and run at set speeds on treadmills while measuring components such as oxygen consumption to estimate hip abductor cost. A limitation of this method is that individuals do not all have the same base walk and run speeds (Warrener et al., 2015). While the notion of sexual dimorphism of the human pelvis is widely accepted, differences between the sexes' energetics in regards to the mechanics of hip abductor muscles appear to be negligible (Dunsworth et al., 2012; Warrener et al., 2015). This result is contrary to the OD hypothesis, which states that females will have higher locomotor costs due to the wider pelvis (Washburn, 1960). Although slight variations in locomotor dynamics

have been seen, they are not significant enough to suggest higher locomotor costs in females and could possibly be indicative of counteractive measures to energetic costs, wherein the muscle is situated differently than the males but works more effectively with a wide pelvis (Dunsworth et al., 2012; Warrener et al., 2015).

The evolutionary cause of sexual dimorphism in human pelvic morphology is uncertain. When pelvic landmarks are measured across a variety of populations, there are multiple explanations within the anterior and posterior spaces (Brown, 2015). Anterior spaces include landmarks such as the inferior ischial tuberosity and the inferior pubis, while posterior spaces include the pelvic inlet and the sacrum. The spaces can be analyzed using body mass as a proxy for biomechanical selective pressures and sex as a proxy for obstetric selective pressures (Brown, 2015). Body mass has the potential to be used as a proxy for biomechanics in this instance because of the impact of weight on locomotion and the proper function of muscles. Comparing results, sections of both spaces show signs of variation due to biomechanics, while other sections within each space show signs of variation due to obstetric pressures (Brown, 2015). These results are difficult to interpret in terms of the obstetric dilemma because they do not illustrate definitive spaces for obstetric and biomechanical pressures within the pelvis; however, these results loosely support the OD because of the influence from both locomotion and obstetrics (Brown, 2015). Tests on the physiology of the human pelvis indicate that there is variation, but that this is not entirely due, or due at all, to the biomechanic energetics of humans. Pinpointing the magnitude of locomotor costs on the anatomy of the pelvic area seems to be more complex than originally thought, especially when incorporating data from both muscles and bone.

According to the OD, the female pelvis would be less variable in morphology compared to males due to the stabilizing effect of the opposing factors, bipedal locomotion and large-headed neonates. Another area of interest when investigating the obstetric dilemma is the variation of the pelvis within and between populations because the stabilizing selection clause of the hypothesis would be upheld by different levels of variation between the sexes (Kurki, 2013). In order to test this, pelvic landmarks must be measured and compared to other individuals in the sample, with the analysis focused on the amount of variation within a sex and between the sexes. However, this assumption has been refuted by evidence which suggests there is no significant difference in skeletal variability levels between the sexes, even across diverse populations (Betti et al., 2013; Kurki, 2013; Kurki & Decrausaz, 2016). Not only this, but the pelvic canal was also found to be just as variable as other parts of the body, such as the limbs, for the same individuals (Kurki, 2013; Kurki & Decrausaz, 2016). It should also be noted that variability of the pelvis can be found amongst monozygotic twins, and not all areas varied the same (Sharma, 2002). Because of findings like these, some propose that any evident variability between the sexes is not produced by obstetric constraints (Gruss & Schmitt, 2015).

Variability of the pelvis has also been linked to body proportions in individuals. While the shape and size of the pelvis have not been found to be uniform within a population, they have shown correlations to the stature and head size of individuals (Fischer & Mitteroecker, 2015). When pelvic landmarks are compared between persons, tall height is connected to narrow pelvises, and large heads are connected to wider canals, regardless of sex (Fischer & Mitteroecker, 2015). Additionally, humans have broad shoulders which further complicate birth and require a large exit much like the head (Trevathan & Rosenberg, 2000). However, the correlation between birth canal proportions and body proportions does not imply causation (Gruss & Schmitt, 2015).

A factor known to cause differences within populations over time is neutral variation, which would imply that the mutation rate of separate groups would be unaffected by outside forces or that no selection was occurring (Betti et al., 2013). The variance of the os coxae of the pelvis is found to be comparable to the pattern of neutral genetic markers, which suggests that neutral evolution, not stabilizing selection, would be a prominent factor in shaping this area of pelvic morphology of local populations today (Betti et al., 2013). This would imply that the variation seen among humans is random change and, if certain pressures shaped it in the past, those pressures are no longer notable. If neutral variation

was indeed the main cause for variation in the pelvis today, this would suggest other factors besides pelvic morphology are important for the determination of human childbearing (Betti et al., 2013).

Environmental components acting on the plasticity of the pelvis could be the cause of the observed variations which contest the obstetric dilemma (Dunsworth et al., 2012; Kurki, 2013; Kurki & Decrausaz, 2016; Sharma, 2002). Variation in the pelvic morphology of monozygotic twins was found in a great deal of the pelvic area and demonstrates the importance of external factors for the development of individual morphology (Sharma, 2002). The range of lifestyles of study participants is a difficult additional variable to account for and may include aspects such as physical activity, diet, and experiences, all of which can alter the morphology of the pelvis (Kurki & Decrausaz, 2016). Furthermore, these aspects may impact natural hormone levels, which may themselves be an important variable in regard to the obstetric dilemma (Betti et al., 2013).

There is also the proposition that the main determining factor for the evolution of human childbearing is the limitation of the maternal metabolism (Betti et al., 2013; Dunsworth et al., 2012; Gruss & Schmitt, 2015; Trevathan, 2015). Pregnancy alters the maternal process of thermoregulation, or the act of obtaining homeostasis; as the fetus develops, it requires more energy from the mother and, by nine months, the maternal metabolism cannot keep up with the demands of the fetus (Dunsworth et al., 2012; Trevathan, 2015). After birth, the child can be fed on breast milk, which is less energetically taxing than development in the womb (Dunsworth et al., 2012). Additionally, it has been proposed that maternal metabolic constraints are more important than locomotion for analyzing current pelvic morphology variation; while locomotion may have been a pressure for selection in the past, this evidence would suggest a shift in selective pressures with emphasis on the limitations of the maternal metabolism (Dunsworth et al., 2012; Gruss & Schmitt, 2015). Dubbed the Energetics and Gestation of Growth (EGG) hypothesis, this new rationale proposes that the fetal brain size is constrained by the maternal metabolism and that the female pelvis adapted to the fetal brain (Dunsworth et al., 2012). The concept of the EGG stems from the lack of evidence for locomotor costs and brain expansion constraints from pelvic mechanics. This hypothesis thus suggests that the fetal brain size is not limited by the pelvis, but that the female pelvis and the fetal brain are both limited by the maternal metabolism; this would also suggest that the maternal metabolism limits the length of gestation, which in turn limits fetal brain size (Dunsworth et al., 2012). The obstetric dilemma details that the mechanical issues brought on by birthing large-headed neonates while maintaining optimal bipedal locomotion shape the morphology of the human pelvis (Washburn, 1960). From the thermoregulation standpoint, pelvic morphology is heavily influenced by the energetics of the mother and not on the mechanics of childbirth (Dunsworth et al., 2012; Gruss & Schmitt, 2015).

Research into the sexual dimorphism of the human pelvis has shown that there are numerous potential pressures that influence morphology. Washburn laid out the obstetric dilemma as an explanation for human pelvic morphology variation, although the predictions made in this hypothesis have received criticism and have been met with conflicting evidence. His ideas about the importance of the opposing forces of obstetrics and locomotion have been argued against, citing other factors such as neutral variation and thermoregulation (Betti et al., 2013). In summary, the obstetric dilemma has been a foundation for decades of research in the field of evolutionary biology, and the findings presented in this review only help to expand the understanding of the evolution of human pelvic morphology.

References

Betti, L., von Cramon-Taubadel, N., Manica, A., & Lycett, S. J. (2013) Global geometric morphometric analyses of the human pelvis reveal substantial neutral population history effects, even across sexes. *PLOS ONE*, *8*(2): e55909. https://doi.org/10.1371/journal.pone.0055909

Brown, K. M. (2015). Selective pressures in the human bony pelvis: Decoupling sexual dimorphism in the anterior and posterior spaces. *American Journal of Physical Anthropology, 157*(3), 428-440. doi:10.1002/ajpa.22734

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. http://doi.org/10.1073/pnas.1205282109

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, 112*(18), 5655-5660. doi: 10.1073/pnas.1420325112

Gruss, L. T., & Schmitt, D. (2015). The evolution of the human pelvis: Changing adaptations to bipedalism, obstetrics and thermoregulation. *Philosophical Transactions of the Royal Society B: Biological Sciences, 370*(1663). doi:10.1098/rstb.2014.0063

Kurki, H. K. (2013). Skeletal variability in the pelvis and limb skeleton of humans: Does stabilizing selection limit female pelvic variation? *American Journal of Human Biology, 25*(6), 795-802. doi:10.1002/ajhb.22455

Kurki, H. K., & Decrausaz, S. (2016). Shape variation in the human pelvis and limb skeleton: Implications for obstetric adaptation. *American Journal of Physical Anthropology, 159*, 630-638. doi:10.1002/ajpa.22922

Sharma, K. (2002). Genetic basis of human female pelvic morphology: A twin study. *American Journal of Physical Anthropology, 117*(4), 327-333. doi:10.1002/ajpa.10055

Trevathan, W., & Rosenberg, K. (2000). The shoulders follow the head: Postcranial constraints on human childbirth. *Journal of Human Evolution, 39*(6), 583-586. doi:10.1006/jhev.2000.0434

Trevathan, W. (2015). Primate pelvic anatomy and implications for birth. *Philosophical Transactions of the Royal Society B: Biological Sciences, 370*(1663). doi:10.1098/rstb.2014.0065

Warrener, A. G., Lewton, K. L., Pontzer, H., & Lieberman, D. E. (2015). A wider pelvis does not increase locomotor cost in humans, with implications for the evolution of childbirth. *PLoS ONE, 10*(3), e0118903. http://doi.org/10.1371/journal.pone.0118903

Washburn, S. (1960). Tools and human evolution. *Scientific American, 203*(3), 62-75. Retrieved from http://www.jstor.org/stable/24940615

Wittman, A. B., & Wall, L. L. (2007). The evolutionary origins of obstructed labor: bipedalism, encephalization, and the human obstetric dilemma. *Obstetrical & Gynecological Survey, 62*(11), 739-748. doi:10.1097/01.ogx.0000286584.04310.5c