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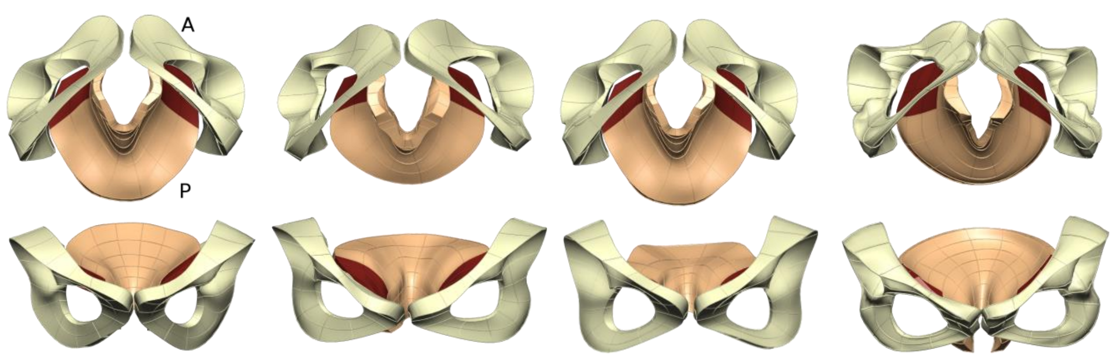
MODELLING EFFECT OF BONY PELVIS ON CHILDBIRTH MECHANICS

<u>Hypothesis / aims of study</u>

The maternal bony pelvis forms the outermost boundary of the birth canal and is of great obstetric importance. The relationship between the dimensions of the bony pelvis, the diameters of the fetal head, as well as the forces required are crucial in determining engagement, rotation, and descent during the second stage of labour. Computer simulations of vaginal delivery have been extensively used to study pelvic floor muscle mechanics; however, the effect of the bony pelvis has not been fully identified. This study uses computer models to investigate the effect of the bony pelvis on the forces required for delivery and the fetal head rotation.

<u>Study design, materials and methods</u>

Pelvic floor models were created from MRI (magnetic resonance imaging) acquired using a Siemens Magnetom Avanto 1.5T scanner in a previous study [1]. Anteroposterior and transverse diameters of the pelvic outlet were measured for healthy nulliparous women without history of pelvic floor dysfunction. One subject was identified to represent each of the gynaecoid, android, and anthropoid pelves. Due to the low prevalence, a typical platypelloid pelvis was absent in the dataset; thus a subject with dimensions close to a platypelloid type was selected (Figure 1). Each MRI dataset was digitised and fitted to create two computer models using in-house software CMISS. The first model consisted of the pelvic floor muscles and part of the anterior pubic bones ("partial pubis", Figure 2a); the second included the pubis, ischium and muscles ("full pelvis", Figure 2b). A fetal head model was generated from a skull replica by ESP Ltd, with a bi-parietal diameter of 90mm and sub-occipitofrontal diameter of 100mm [2]. The head engaged in an occiput-anterior position and descended vertically with the ability to translate and rotate, negotiating its way through the birth canal.

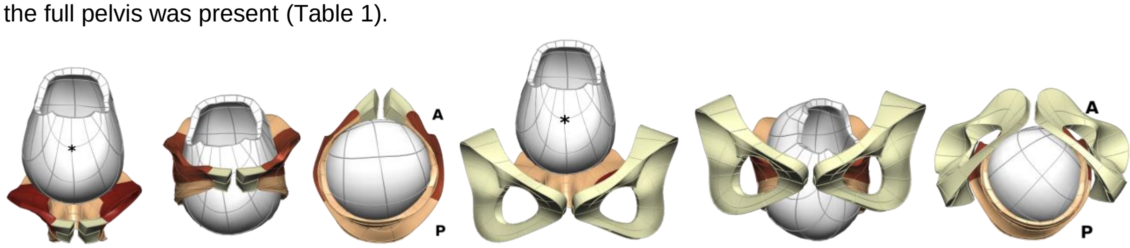


Android Platypelloid Anthropoid Gynaecoid

Figure 1: Pelvic floor models with full pelvis. Views are caudal (top row) and anterior (bottom row).Beige, levator ani; dark red, obturator internus; cream, bony pelvis.
A, anterior; P, posterior.

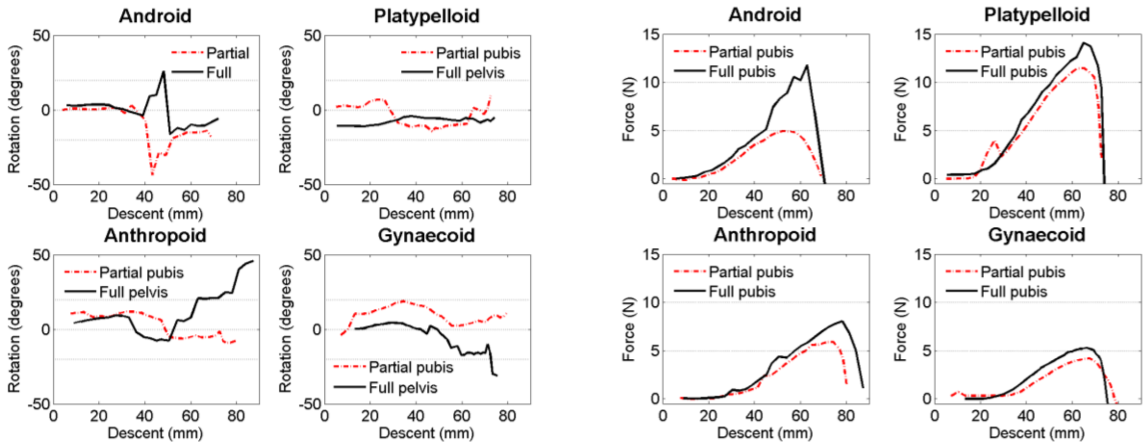
<u>Results</u>

Figure 3 illustrates the fetal head rotation and forces required for delivery over the course of descent. Compared to the corresponding models with a partial pubis, larger rotation was observed in the full pelvis models of gynaecoid and anthropoid types. For the platypelloid type, the full pelvis gave rise to a different fetal head motion, despite the magnitude of maximum rotation being similar to that observed in the model with a partial pubis. The android full pelvis hindered fetal head rotation. In all four cases, fetal head rotated to the opposite direction at the moment of crowning and required a larger force for delivery, when the full pelvis was present (Table 1).



anterior caudal anterior caudal
(a) (b)

Figure 2: Childbirth models with a partial pubis (a) and a full pelvis (b). Anthropoid type.
Beige, levator ani; dark red, obturator internus; cream, bony pelvis; silver, fetal head;
A, anterior; P, posterior; asterisk, foramen magnum.



(a) (b)

Figure 3: Fetal head rotation (a) and forces required for delivery (b) versus descent. Positive rotation, left occiput-anterior; negative rotation, right occiput-anterior.

Table 1: Summary of maximum fetal head rotation and force required for delivery. Positive rotation, left occiput-anterior; negative rotation, right occiput-anterior.

Pelvis type	**Max. rotation (degree)**		**Max. force (N)**	
	Partial pubis	Complete pelvis	Partial pubis	Complete pelvis
Android	-44	+26	5	12
Platypelloid	-15	-11	11	14
Anthropoid	+12	+48	6	8
Gynaecoid	+19	-31	4	5

Interpretation of results

Incorporation of the full pelvis provides a more complete anterior constraint to the childbirth model. Preliminary results indicate models with only the partial pubis are likely to under-estimate forces required for delivery. The fetal head motion was noticeably different when a full pelvis is present, implying a full set of pubic rami is necessary to more realistically simulate the mechanics of childbirth. This is consistent with clinical observation, as the pelvic outlet is formed by the posterior border of the pubic rami, the ischial spines and the base of the coccyx. The complete pelvis seems to facilitate fetal head rotation for gynaecoid and anthropoid type of pelves. Android full pelvis hindered rotation, which led to the largest increase in force required for delivery and could potentially induce a more difficult childbirth.

Concluding message

We have quantitatively investigated the effect of the maternal bony pelvis on childbirth mechanics using individual-specific computer models. In the future, to make this framework more realistic and suitable as an educational and diagnostic tool, other structures including the external sphincter and perineal body will be incorporated.

References

1. Obstet Gynecol (2008) 111(3); 631-638
2. J Biomechanics (2001) 34; 1125-1133

Disclosures

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