83

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HOW MUCH DOES THE PUBORECTALIS MUSCLE HAVE TO STRETCH DURING CHILDBIRTH?

Hypothesis / aims of study
Biometry and function of the levator ani muscle in the human female is likely to be of importance for vaginal childbirth. The birth canal is defined not only by the rigid bony pelvis but also by the levator. The main purpose of this muscle in the human female is to close off the abdominal cavity caudally while allowing for elimination of faeces and urine and intercourse, requiring limited dimensions and distensibility. Vaginal childbirth implies an entirely different set of requirements. The levator has to distend to a much greater degree, preferably without reaching its elastic limit. The crucial moment in testing muscle properties is the late second stage of labour and crowning of the fetal head. There have been attempts at defining the distension required for vaginal childbirth with the help of datasets acquired with magnetic resonance imaging(1), but it is clear that hiatal dimensions and distensibility are likely to vary greatly between individuals. This study was designed to define the degree of stretch/strain required of the puborectalis component of the levator ani in childbirth.

Study design, materials and methods
We examined 227 nulliparous women at 36-38 week's gestation. The assessment consisted of a history, a clinical examination including Bishop Score, and 4D ultrasound imaging using a GE Kretz Voluson 730 Expert system. Volume data sets were acquired with the patient supine with empty bladder at rest, on maximal Valsalva and during pelvic floor muscle contraction (PFMC). The stored volumes of 224 women were processed using proprietary software; 3 datasets were missing when post-processing was undertaken. Minimal hiatal diameters, circumference and area were measured as previously described (2); see Figure 1 for a representation of axial plane imaging on Valsalva.

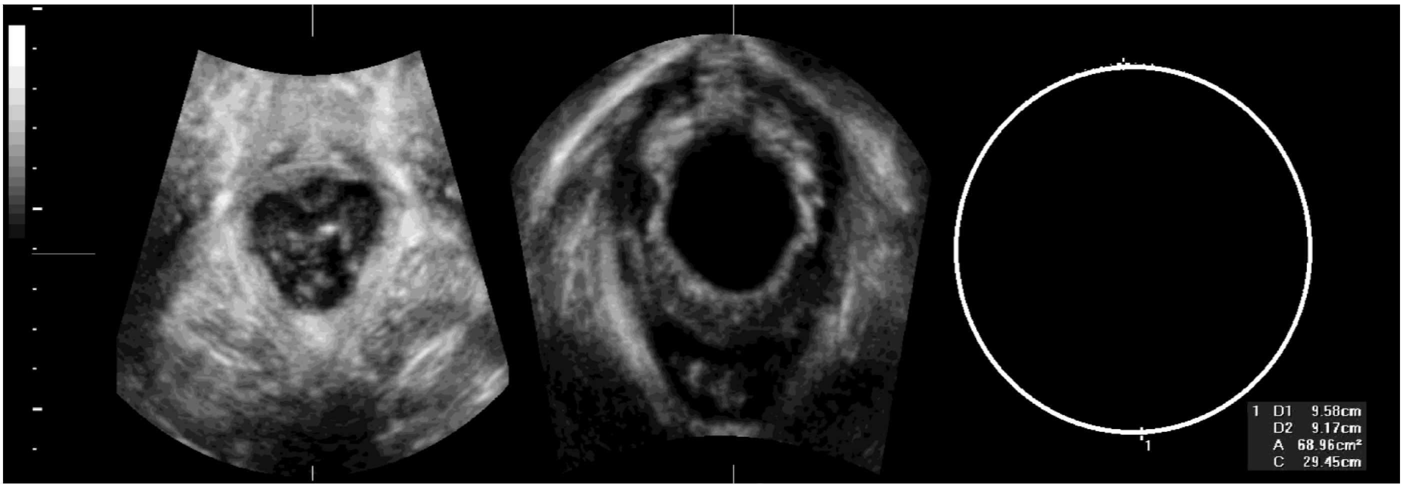

Figure 1: The levator hiatus in the axial plane on Valsalva in patients with minimally distensible (left) and highly distensible puborectalis muscle (middle), compared to the dimensions of a Caucasian fetal head at term (right).

In order to determine muscle strain, we measured the bony part of the hiatus, and this was subtracted from the circumference to obtain the muscular component of the levator hiatus. To estimate required distension at vaginal birth we used neonatal biometric data obtained in a Caucasian population (http://www.pubcare.uu.se/ubcos/birth/stbirth.htm#NY78B). Assuming an ellipsoid shape of the fetal head and a circumference determined by the biparietal and sub-occipito-bregmatic diameters we calculated a mean circumference of 29.3 cm. Subtraction of individual bony arc measurements (l_b) resulted in the required muscular length (RML). The 'strain' or 'stretch ratio' of the muscle required to allow delivery of a Caucasian baby of average size was calculated as previously described(3), both from dimensions at rest and on maximal Valsalva (see Formula 1). The data was analysed with descriptive statistics.
Formula 1: $E_{req} = (C_{reg}-C_{rest}) / (C_{rest} - l_b)$
where E_{req} *= strain to reach the required muscular length;* C_{reg} *= required hiatal circumference for delivery of an average Caucasian baby;* C_{rest} *= hiatal circumference at rest;* l_b *= bony arc length*

Results
We analysed the volume datasets of 224 nulliparous women at a mean gestational age of 37.1 weeks (range 35.6 - 39.1). The mean BMI before pregnancy was 24.96 (15.3- 46.33), BMI at examination 30.61 (19.37 – 50.29), and mean age was 25.4 years. Over 91% of women were of Caucasian background (6% part Caucasian, 3% Asian, Polynesian or Indian).

Table 1 gives the descriptive statistics for hiatal dimensions at rest and on Valsalva. The mean strain (stretch ratio) required for vaginal delivery (assuming an average Caucasian baby delivered from the occipito- anterior position) was calculated as 1.46 (range 0.61 - 2.74; SD 0.39) from resting length, and 1.06 (range 0.24 - 2.43; SD 0.43) when calculated from dimensions at maximal Valsalva. This implies that, from dimensions at maximal Valsalva, some women will have to distend the levator hiatus by only 24%, others by 243% (Fig 2).

Table 1: (cm)	Mean	Max	Min	SD
Sagittal diameter at rest	5.51	7.42	3.62	0.75
Coronal diameter at rest	3.82	5.48	2.48	0.45
Hiatal circumference at rest	14.74	20.35	10.81	1.67
Hiatal area at rest (cm^2)	14.13	24.37	8.33	3.05
Sagittal diameter on Valsalva	6.28	9.31	3.78	1.09
Coronal diameter on Valsalva	4.29	6.26	2.75	0.57
Hiatal circumference on Valsalva	16.98	24.36	11.47	2.61
Hiatal area on Valsalva (cm^2)	20.17	42.39	9.74	6.47
Bony arc length	4.37	5.87	2.96	0.59

Table 1: Hiatal dimensions in 224 nulliparae in late gestation

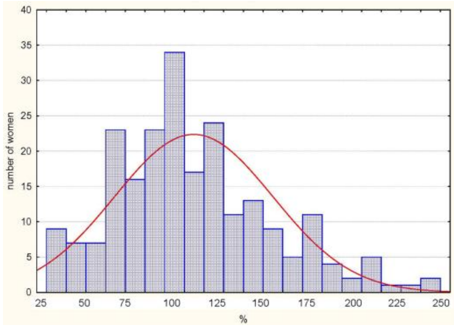

Figure 2: Histogram of required strain from Valsalva

Interpretation of results:

It is a basic fact of clinical obstetrics that the ability of women to give birth vaginally seems to vary greatly. This is thought to be due to variations in the propelling force ('propulsion'), the position and size of the fetus ('passenger') and differences in the size and compliance of the birth canal ('passages'). In the past the bony dimensions of the pelvis were held to be of paramount importance. Recently, both this group and others have been able to show that dimensions of the levator hiatus are associated with obstetric performance. Others have used computer modelling to estimate the degree of distension required for vaginal delivery. In this study we have obtained normative data for the required distension of the puborectalis muscle in a largely Caucasian population. It appears that the population distribution for this parameter is very wide. The strain required for vaginal delivery of an average sized Caucasian baby, on top of the distension obtained by maximal Valsalva, varied from 24% to 243%, that is, by a factor of 10. We are in the process of testing the parameters described here for their value as surrogate measures of pelvic floor muscle compliance, analysing their predictive value for obstetric performance and delivery- related pelvic floor trauma.

Concluding message:

There are enormous inter-individual variations in the distension required of the puborectalis muscle in Caucasian women at term, even assuming an optimal fetal position. It is entirely plausible that in some women the required distension will result in the muscle reaching its elastic limit, causing permanent injury. The wide population spread for required puborectalis muscle strain documented in this study questions the appropriateness of using individual imaging datasets for modelling pelvic floor function in childbirth, and may explain some of the variation in obstetric outcomes observed in nulliparous women.

References:

1. Obstet Gynecol 2004; 103: 31-40.
2. Ultrasound Obstet Gynecol 2005; 25: 580-585.
3. Ultrasound Obstet Gynecol 2008; 31: 201-205.

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Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**Sydney West Area Health Service Ethics Committee**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**