

## CONTRIBUTIONS OF THE LEVATOR ANI COMPONENTS TO THE URETHRAL SUPPORT FUNCTION IN WOMEN

### Hypothesis / aims of study

Levator ani (LA) muscles which consist of the iliococcygeus, puborectalis, and pubococcygeus muscles are believed to play a significant role in the urethral support system [1]. However the relative importance of the three LA muscle components in contributing to the urethral support function remains unclear. The aim of this study is to specify the contributions of the three LA muscle components to the urethral support function in women using a subject-specific pelvic modelling approach.

### Study design, materials and methods

Anatomic pelvic MR images of an asymptotic female subject were used to construct a comprehensive pelvic model by using the developed subject-specific pelvic model generation approach [2]. A smooth loading step was employed to increase the pressure of the bodyfill part of the pelvic model from 0 to 80 cmH<sub>2</sub>O to mimic the increasing intra-abdominal pressure (IAP) during pressure events. Linear elastic properties were assigned for all parts in the model according to their biological tissue types [3]. The elastic modulus of a specific LA component or a combination was reduced at each time in the pelvic model to mimic the weakness of the component or combination. The dynamic biomechanical analysis was performed based on the pelvic model, and the urethral angular changes were calculated for each different weakness condition to evaluate the contribution of different LA muscle components to the urethral support function.

Two sets of simulations were performed, as shown in Table 1. In set 1 we tested cases with only one LA muscle component being weakened, to characterize the contribution of each individual LA muscle component to the urethral support function. In test 2 we tested cases with a combination of LA muscle components to characterize their combined contribution to the urethral support function.

### Results

The urethral angle changes (UACs) were plotted against intra-abdominal pressure (IAP) for each test in order to investigate the trend of the loss of the urethral support function, as shown in Figure 1. The referenced UACs as shown in Table 2 were also calculated by subtracting the UAC achieved in the asymptomatic pelvic model from absolute UACs achieved for each weakness condition under the final IAP of 80cmH<sub>2</sub>O.

<i>Test #</i>	<i>Weakened Muscle(s)</i>	<i>Test #</i>	<i>Referenced UAC</i>
00	None (asymptomatic model)	00	0.0
<b>Set1</b>		<b>Set1</b>	
01	Iliococcygeus	01	0.2
02	Puborectalis	02	14.2
03	Pubococcygeus	03	1.1
<b>Set2</b>		<b>Set2</b>	
04	Puborectalis + Pubococcygeus	04	17.1
05	Levator Ani	05	22.6

Table 1: Design of simulations

Table 2: Referenced UAC at 80cmH<sub>2</sub>O

### Interpretation of results

A strong linear relationship was observed for all UAC-IAP curves in Figures 1. The results demonstrated that the iliococcygeus, puborectalis and pubococcygeus muscles contributed variously to the urethral support system. Weakening the puborectalis muscle among these three LA components generated the largest UAC, whereas weakening the other two components generated much lower UACs.

A referenced UAC of 17.1° was achieved at 80cmH<sub>2</sub>O in test04 when both puborectalis and pubococcygeus muscles were weakened, which is 11.8% larger than the sum of referenced UACs achieved by weakening each individuals in the test02 and test03. A referenced UAC of 22.6° was achieved at 80cmH<sub>2</sub>O in test05 when all the three LA muscle components were weakened, which is 45.8% larger than the sum of the three UACs achieved by weakening each individuals (test01-03). The results revealed that the linear superposition does not hold in evaluating the degree of loss of the urethral support function caused by different LA muscle components. Weakening multiple LA parts together will result in a larger degree of loss of urethral support function than the simple addition of weakening each of them separately.

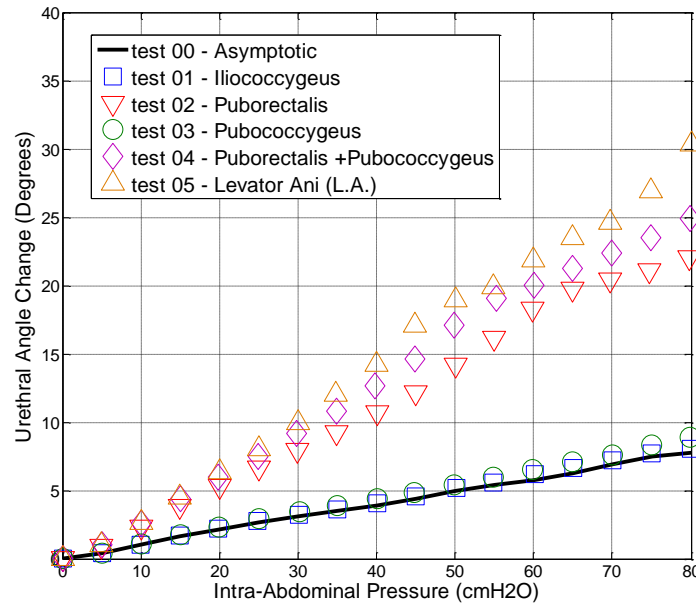


Figure 1. Changes of UACs achieved at different weakness conditions against increasing IAPs

#### Concluding message

In conclusion, we observed a strongly linear trend in the urethral angle changes against the increasing IAPs under all weakness conditions. Among the three LA muscles components, the puborectalis muscle provides the most important contribution to the urethral support function. A non-additive relationship of urethral support function loss was found in testing different LA components.

#### References

1. Delancey, J.O.L. and J.A. Ashton-miller, Pathophysiology of adult urinary incontinence. *Gastroenterology*, 2004. 126, Supplement 1(0): p. S23-S32.
2. Zhang, Y., et al., Advanced finite element mesh model of female SUI research during physical and daily activities. *Stud Health Technol Inform*, 2009. 142: p. 447-452.
3. Zhang, Y., et al., Feasibility of using a computer modeling approach to study SUI induced by landing a jump. *Annals of biomedical engineering*, 2009. 37(7): p. 1425-1433.

#### Disclosures

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