THE RELATIONSHIP BETWEEN INTRAVAGINAL AND URETHRAL PRESSURE DURING VOLUNTARY CONTRACTION AND DURING COUGHING IN CONTINENT WOMEN

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INTRODUCTION

Vaginal pressure is frequently used as a measure of pelvic floor muscle (PFM) function and as a surrogate measure for urethral closure pressure in physiotherapy research and practice [1]. Vaginal pressure measurements during dynamic activities such as PFM contraction or coughing have not been compared with urethral pressure measurements to determine if they do, in fact, provide a valid representation. We hypothesized that pressure increases recorded in the vagina would reflect the functional outcome of PFM contraction as it pertains to increases in urethral closure pressure and would accurately reflect intra-urethral pressure generated during coughing. Due to its closer proximity to the urethra, pressure recorded adjacent to the anterior vaginal wall was hypothesized to be more strongly correlated with urethral pressure than is pressure recorded adjacent to the posterior vaginal wall.

METHODS

This was a cross-sectional observational study. Women without neurological or rheumatological diagnoses, diabetes, prolapse ≥ POP-Q stage II or previous pelvic surgery were recruited. All participants provided informed, written consent. Demographic data were recorded and volunteers completed the Urogenital Distress Inventory (UDI). The women were taught how to correctly perform a PFM contraction, confirmed by vaginal palpation and observation. Urethral pressure was measured using a saline-filled, 8 French triple lumen catheter interfaced with a Becton Dickinson DTX™ Plus DT-12 pressure transducer. The catheter opening was positioned in the urethra at the point where the transducer recorded the highest pressure values during both a PFM contraction and a cough. Vaginal pressure data were recorded adjacent to the anterior and posterior vaginal walls using two air-filled, 10 French rectal balloons mounted on the anterior and posterior surfaces of a vaginal probe, which were interfaced with Motorola MPX5010 Integrated Silicon pressure transducers. Data were recorded using Delsys EMGWorks™ Acquisition software at a sampling rate of 1000 Hz while, in supine the volunteers performed three maximum voluntary PFM contractions (PFM MVCs) and in standing they performed three PFM MVCs and three maximum effort coughs.

All data were dual filtered using a third order, 5Hz low pass Butterworth filter. The filtered mean of the first 100 data points was subtracted from each data file. The peak pressure was determined for each pressure recording site during each repetition of each task. The peak pressures were compared among the pressure recording sites and tasks using a repeated measures analysis of variance (ANOVA) ($\alpha=0.05$). For each task, the peak pressures were compared among pressure recording sites by calculating the regression of the peak urethral versus peak vaginal pressure curves. Cross-correlation functions were computed among the urethral, anterior vaginal, and posterior vaginal pressure curves. Lastly, ensemble averaged urethral pressure versus vaginal pressure curves were created during the rising phase of urethral pressure during each task.

RESULTS AND DISCUSSION

Eleven women participated. The sample had a median (range) age of 42 (29 to 68) years, body mass index of 26.7 (18.9 to 29.7) kg/m², UDI score of 3/19 (0 to 8), and had 2 (0 to 4) children and had 2 (range 0 to 2) vaginal deliveries.

The peak urethral pressure was higher during coughing than during either the supine or the standing PFM MVCs ($p<0.001$ for both). There was no difference between the peak urethral pressure generated during the supine and standing PFM MVCs ($p=1.00$). There was no difference in peak
intravaginal pressure among the three tasks for either the anterior or the posterior pressure recording site (p=1.00 for both). Peak urethral pressure was linearly related to peak intravaginal pressure (slopes= 3.53 to 3.66 for the PFM MVCs and 6.89 for the cough; p<0.001 for all tasks). The cross-correlation coefficients between urethral and vaginal pressure and between anterior and posterior vaginal pressure were all high (r>0.96). The relationship between the generation of urethral pressure and the generation of intravaginal pressure is presented in Figure 1. The rise in urethral pressure was highly correlated with that of anterior (slope= 0.768 ±0.030, p<0.001) and posterior (slope= 0.772 ±0.092, p<0.001) vaginal pressure recorded during coughing. The relationship between urethral and vaginal pressure was also linear during the standing PFM MVCs, but the slopes were much lower (anterior slope=0.252 ± 0.049, p<0.001, posterior slope=0.321 ±0.043,p<0.001) and more variable. The relationship between urethral pressure and vaginal pressure was curvilinear during the supine PFM MVCs.

It appears that women do not generate maximal urethral closure pressure when performing a PFM MVC, however the difference in peak urethral pressure between PFM MVC and coughing was not reflected in the intravaginal pressure measurements. Peak pressure recorded using the anterior vaginal transducer was not different from that recorded using the posterior vaginal transducer, and there was no difference in the ensemble averaged urethral pressure versus anterior and posterior vaginal pressure curves for any of the three tasks. As such, the location of the pressure transducers within the vagina (anteriorly or posteriorly) appears to be of no consequence on experimental results.

Based on the urethral vs vaginal pressure curves, it appears that pressure generated from a PFM MVC is evident in the vaginal pressure before it is evident in the pressure measurements. This delay may be related to the electromechanical delay between muscle activation and force output and/or due to time required to take up slack in the pelvic supporting tissues before pressure can be transmitted to the urethra. Coughing, which is a more explosive task, appears to demonstrate more rapid transmission of forces from the vagina to the urethra, but these forces are more likely related to the abrupt rise in intra-abdominal pressure rather than pressure induced by PFM contraction.

CONCLUSIONS

While it must be recognized that urethral pressure includes components generated by the urethral sphincters and passive tissue stiffness that do not contribute to intravaginal pressure, this study has demonstrated that intravaginal pressure recorded adjacent to both the anterior and posterior vaginal walls is strongly correlated with urethral pressure and can be used as a surrogate for urethral pressure measures in biomechanical studies of the continence system and as a functional outcome measure in physiotherapy.

REFERENCES

ACKNOWLEDGEMENTS

Funding for this research was provided by the National Sciences and Engineering Research Council of Canada (NSERC).

Figure 1: Ensemble average curves for urethral pressure versus anterior vaginal pressure during a. PFM MVC performed in supine, b. PFM MVC performed in standing, c. Maximal effort cough performed in standing.