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SYNERGISTIC ABDOMINAL MUSCLE ACTIVITY IN RESPONSE TO VOLUNTARY PELVIC FLOOR MUSCLE CONTRACTIONS IN CONTINENT WOMEN, IN SUPINE, SITTING AND STANDING.

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

We hypothesized that, in urinary continent women performing maximal voluntary pelvic floor muscle (PFM) contractions, there would be a quantifiable synergistic pattern of abdominal muscle and PFM activation and that the relative PFM activation levels and intravaginal pressures generated during these contractions would be higher in sitting and standing than in supine.

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

A cross-sectional descriptive statistical design was used. Women aged 21 to 60 with no history of incontinence or use of medications known to exacerbate incontinence were recruited.

A single use vaginal surface electromyography (EMG) probe was used for data acquisition from the PFM. The probe was modified to collect pressure data with two balloons connected to pressure transducers: an upper balloon to predominantly record intra-abdominal pressure and a lower balloon to record pressure generated by the PFM. Surface EMG data were recorded from the right rectus abdominis, transversus abdominis, external oblique and internal oblique muscles. All EMG data were amplified using Bortec AMT-8 amplifiers and a gain of 1000, and both EMG and pressure data were acquired at 1kHz using a 16-bit Analog to Digital Converter and Labview v.6.1. After the subjects performed two maximal voluntary contractions (MVCs) of each of the abdominal muscles being studied, the PFM testing positions (supine, sitting and standing) were presented in random order, and in each position, the participants performed three attempts to maximally contract their PFM and three repetitions of a 30-second series of PFM MVCs.

The data from the 30-second series of repeated contractions were full wave rectified and filtered (forward and back) using a third order Butterworth filter with 5 Hz cut off. Cross-correlation functions were computed to determine the relationships (correlation coefficients and time delays) between the PFM and abdominal muscle activation patterns. Two-way analyses of variance (ANOVAs) were performed to compare the time lags between testing positions and muscles (alpha=0.05). Data from the maximal contractions were smoothed by computing root mean square (RMS) values using a 200ms moving window across each pressure and EMG data set. The RMS value of the resting activity was subtracted from the maximal values for each muscle and each contraction, and the highest value from each channel was deemed to be the maximum voluntary electrical activity (MVE) of that muscle during that contraction. Two-way repeated measures ANOVAs were performed to determine the effect of testing position on the EMG and pressure data. Bonferroni post hoc tests were performed (alpha=0.05) to test pairwise comparisons.

<u>Results</u>

Fifteen women, mean age 36.3 (SD 9.9) years participated. Three were parous. All were able to correctly perform a PFM contraction as determined by observing the cephalad movement of the testing probe during contractile efforts.

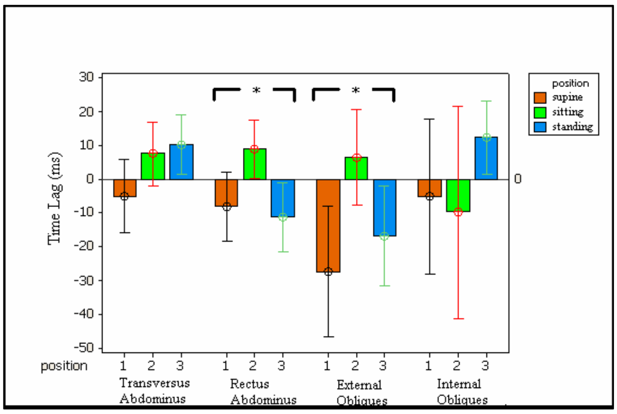

Figure 1: Abdominal muscle activation times relative to the onset of the PFM (time lag =0). '*' denotes significant position effects, bars denote 95% confidence intervals. The transversus abdominus and internal obliques were not activated at a different time than the PFM ($p>0.05$). In supine and standing the rectus abdominus ($p<0.01$) and external obliques ($p<0.02$) were activated before the PFM, whereas in sitting they were activated after the PFM.

The cross-correlation analysis determined that the activity of all of the abdominal muscles was highly correlated with that of the PFM (r>0.85). The ANOVAs revealed that there were significant muscle by testing position interactions for the external obliques (p<0.02) and rectus abdominus (p<0.01) muscles, but not for the others. In supine and standing the rectus abdominus and external oblique muscles came on before the PFM, whereas in sitting the rectus abdominus and external oblique muscles came on after the PFM. With the position data pooled for the internal obliques and transverses abdominus muscles, there was no difference in onset times between these muscles and the PFM. See Figure 1 for details.

The comparison of EMG amplitudes by position revealed that activation amplitude was dependent on position (p<0.01) and that muscles were activated at significantly different levels from each other (p<0.01). There was no position by muscle interaction effect (p=0.40). The EMG amplitudes were highest in supine and not different between sitting and standing (Figure 2). There was an interaction between pressure transducer site and subject position. Post-hoc tests (fixing one factor to test the other) revealed that intravaginal pressure was higher in sitting and standing than in supine(p<0.01) and that pressure was not different between sitting and standing. It was also found that the upper and lower balloon pressure recordings were significantly different from each other in each position (p<0.01).

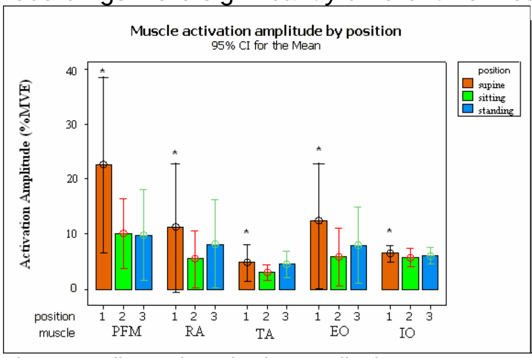

Figure 2: All muscle activation amplitudes were significantly higher in supine as compared to sitting and standing (*). Activation amplitudes in sitting and standing were not significantly different.

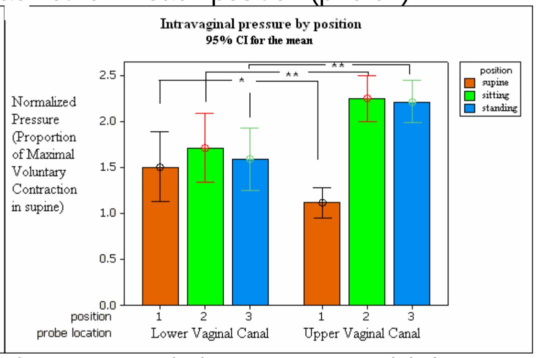

Figure 3: Intravaginal pressure generated during a PFM contraction was higher at the lower probe site when the subject was supine (*) but was higher at the upper probe site when the subjecs were upright (**).

Interpretation of results

In standing, there was a predictable pattern of muscle activation onset, whereby the external obliques were activated before rectus abdominus, and these muscles were followed by the PFM. The internal obliques and transverses abdominus were activated after the PFM. There was a trend towards this pattern in supine, whereby the external oblique muscles were again activated prior to the onset all other muscles, however in this case it appears that there was inadequate power to determine distinct onset time for rectus abdominus prior to the PFM internal obliques and transverses abdominus. In sitting, there was no clear pattern of activation. Activation amplitudes for all muscles were higher in supine than in the other positions. For the abdominal muscles, this might be an artifact of differences in the muscle-electrode-tissue geometries, however for the PFM this is unlikely the case. The higher PFM activation in supine might be real or might be an artifact caused by shifting of the electrodes away from the attachment of the PFM to the lateral vaginal wall.

The pressure behaved as expected in each of the positions. The increase in the upper vaginal pressure in the upright positions was probably due to gravity pulling on the abdominal organs. The lower vaginal pressure seems to be relatively independent of abdominal pressure, as its maximum rise over the baseline level was not affected by body position.

Concluding message

The differences in activation patterns among positions might be responsible for the increased number of incontinence episodes experienced by women when in the seated position. It appears that the external oblique and rectus abdominus muscles may generate an increase in intra-abdominal pressure which may stimulate contraction of the PFM, effectively squeezing the urethra to prevent urine leakage. The muscle synergies were able to generate an equally effective intravaginal pressure in supine as in sitting and standing despite the observed differences in activation patterns.

FUNDING: Physiotherapy Foundation of Canada