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The impact of state of bladder fullness on tonic and phasic activation of the pelvic floor muscles in women

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ABSTRACT

Purpose: We aimed to determine if state of bladder fullness affects pelvic floor muscle activation in healthy women without urogenital symptoms.
Materials and methods: Twenty-three nulliparous, continent female participants were recruited to participate. Women were randomized to begin the protocol with either an empty (EF) or a full (FE) bladder. Tonic and maximal voluntary pelvic floor muscle electromyographic activity were measured in three states of bladder fullness (empty, full and uncomfortably full). Electromyographic signal amplitudes were compared among bladder states using separate two-way repeated-measures analyses of variance including bladder state and test order as main effects as well as the interaction between bladder state and test order.
Results: Tonic activity of the pelvic floor muscles was significantly higher in the full and uncomfortably full bladder states compared to when the bladder was empty ($p < 0.005$). Maximum voluntary electromyographic activation was unaffected by state of bladder fullness ($p = 0.713$).
Conclusions: Consistent with studies in which the bladder was filled through saline infusion, these results suggest that tonic activity of the PFMs is higher when the bladder is full compared to when it is empty. However once the bladder is moderately full, tonic PFM activity does not increase with increases in bladder volume.

1. Introduction

The pelvic floor muscles (PFMs) have demonstrated roles in continence control, sexual function, pelvic organ support, and lumbopelvic stability, and often these functions occur concurrently. When contracted, the PFMs compress the urethra against the anterior vaginal wall, which assists in generating urethral closure pressure to prevent urine leakage (Ashton-Miller and DeLancey, 2007), sharpen the anorectal angle to promote fecal continence (Rostaminia et al., 2014), and reduce the area of the levator hiatus to support the pelvic organs (Dietz and Simpson, 2008). PFM strength has been positively associated with sexual arousal and pleasure (Martinez et al., 2014). In women, insufficient PFM activation is associated with urinary (Bump and Norton, 1998) and fecal (Brusciano et al., 2007) incontinence. An inability to relax the PFMs has been associated with post-partum low back and pelvic pain (Pool-Goudzwaard et al., 2005) vulvovaginal pain disorders (Shafik and El-Sibai, 2002) and chronic constipation (Ribas et al., 2011; Shih and Kwan, 2007).

The recruitment and inhibition of the detrusor, urethral sphincter, anal sphincter, and PFMs are mediated by a complex interaction between voluntary and reflex systems (Vanderhorst et al., 1996; McMahon et al., 1982). As one example, PFM contraction is known to be inhibitory to detrusor contraction, a reflex that is exploited in the physiotherapy management of individuals with overactive bladder syndrome (Shafik and Shafik, 2003). During sexual activities, a contraction of the bulbocavernosis in men is accompanied by contraction of the external anal sphincter (Shafik et al., 2004). By the very nature of the many roles of the

Abbreviations: DSE, differential suction electrode; EF, those who performed the protocol int the order of empty bladder then full bladder; EMG, electromyography; FE, those who performed the protocol in the order of full bladder then empty bladder; MVC, maximum voluntary contraction; MVEA, maximum voluntary electrical activation; PFMs, pelvic floor muscles; RM-ANOVA, repeated-measures analysis of variance; RMS, root mean square.

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PFMs, individuals may frequently face situations where there are concurrent or competing demands for PFM contraction and/or relaxation. Little is known about how competing task demands are resolved, or how changes induced by reflex activation impact voluntary activation of the PFMs.

Sørensen (1989) and Vereecken and Verduyn (1970) both reported an increase in tonic PFM electromyographic (EMG) activity during bladder filling using a saline-infused catheter, but the activation was not quantitatively analyzed. Deindl et al. (1993), found increases in tonic PFM activity in 8 of 10 continent women when their bladder was full as compared to when it was empty. However, in these studies the bladder filling was induced by catheter, which is more rapid than normal physiological filling and therefore may have a different effect on the reflex mediated activation of the PFMs.

Studies by Smith et al. (2007a,b), examined, in women, differences in tonic and automatic activation of the PFMs associated with a load catching task when the bladder was full compared to when it was empty. In these studies, bladder filling occurred naturally, and, contrary to the earlier studies noted above, Smith et al. (2007a,b) found that women had no difference in tonic PFM activity when their bladders were full compared to when they were empty. They suggested that their findings may have differed from those of Sørensen (1989) and Deindl et al. (1993) due to the use of a urethral catheter for bladder filling, which they claimed may have caused reflex activity not normally present during natural bladder filling. The difference in the results may, however, have been related to the type of instrumentation used, specifically the location and type of EMG electrodes. Sørensen (1989), Deindl et al. (1993) and Vereecken and Verduyn (1970) all used paired hook wire electrodes placed within the PFMs whereas Smith et al. (2007a,b) used a pair of large surface electrodes mounted on either lateral side of an intravaginal probe, effectively recording a differential between the right and left vaginal walls, and which would likely have recorded crosstalk, particularly given that their participants were studied in a standing position (Keshwani and McLean, 2015). Interestingly, despite finding no effect of bladder fullness on tonic PFM activation, Smith et al. (2007a,b), did find that having a full bladder increased the tonic activity of the abdominal and erector spinae muscles and suggested that this response was the result of increased corticospinal excitability to the postural trunk muscles induced by the full bladder state.

The literature is unclear with regards to the effect of bladder fullness, when the bladder is filled naturally, on tonic and/or voluntary PFM activity. This relationship has been largely unaccounted for in studies of PFM activation, although it has been noted as a potential confounding factor (Auchincloss and McLean, 2009; Brostrøm, 2003). The purpose of this study was to determine whether the state of bladder fullness affects PFM tonic or maximal activation levels in healthy women with no evidence of or major risk factors for PFM dysfunction.

2. Materials and methods

This study was approved by the Queen's University Health Sciences Research Ethics Board and all subjects provided written informed consent prior to participation.

2.1. Participants

Healthy nulliparous females were recruited from the university community to participate in this study. Women were excluded if they had a history of any disorder that might affect or be associated with impaired PFM function including incontinence, voiding urgency, chronic constipation, genital pain, pelvic organ prolapse, gynaecological surgery, overweight (BMI > 24.9 kg/m^2), and/or pregnancy beyond the second trimester. Based on Smith et al. (2007b), it was determined that a sample size of 12 women would be adequate to provide power of 0.80 at an alpha level of 0.05; we recruited 24 women to participate. Prior to their experimental session, participants were randomized, using a computerized randomization scheme, to begin the study with either a full (FE) or empty (EF) bladder to avoid confounding effects related to state of arousal or muscle fatigue on the experimental outcomes. All participants in the FE group (n = 12) were asked to avoid voiding their bladder for two hours prior to testing and to drink 500 mL of water one hour prior to testing. Participants in the EF group (n = 12) were asked not to drink anything for two hours prior to the testing and to void immediately before testing began.

On arrival at their experimental session, participants first provided basic demographic information (age, height, weight) and underwent a digital palpation examination of their PFMs by a physiotherapist with post-graduate training and experience in PFM assessment. Participants were instructed verbally on how to perform a proper PFM contraction, and tactile feedback was used to assist motor learning. A proper PFM contraction was defined as one in which both a squeeze and lifting action were palpated manually. Women were instrumented only once they demonstrated the ability to consistently perform this contraction.

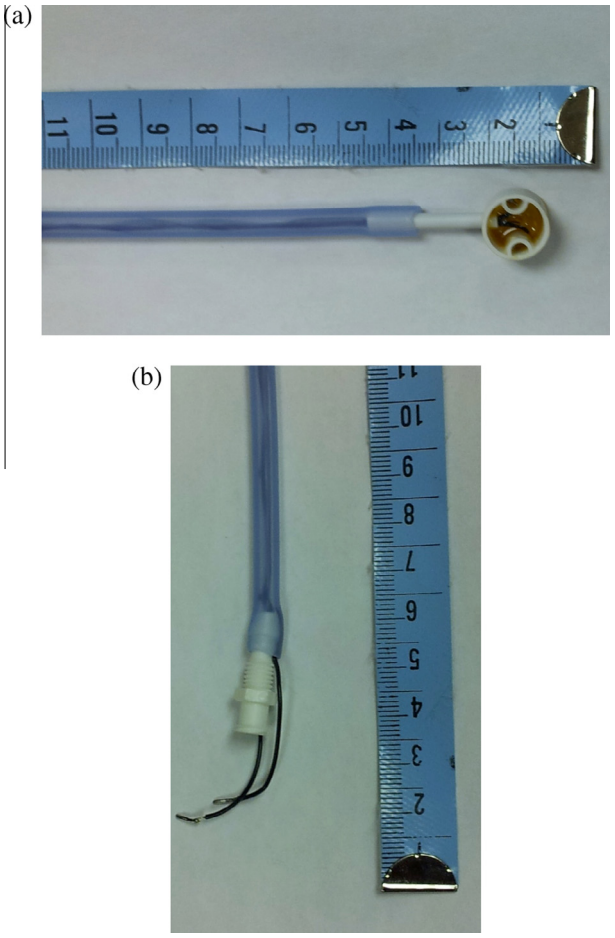

Fig. 1. Differential suction electrode (DSE) depicting: (a) the suction head on the proximal end of the electrode that is positioned and suctioned onto the vaginal wall adjacent to the PFM's, and (b) the distal end of the electrode where the syringe is attached to apply the suction force through the catheter tubing. The electrodes are connected to the amplifier cables through insulated microgator clips.