Pelvic floor tissue damping during running using an intra-vaginal accelerometry approach

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Abstract

Background: While cumulative loading of the pelvic floor during exercise appears to increase the risk of developing pelvic floor disorders, the pathophysiologic role of pelvic floor loading is poorly understood. The aim of this exploratory study was to present a method for evaluating vibrational frequency damping of the female pelvic floor and to investigate the potential utility of this approach in a preliminary evaluation.

Methods: Female participants were instrumented with an intravaginal accelerometer and a hip-mounted accelerometer, then ran on a treadmill at 7 km/h and 10 km/h both before and after a 30-min self-selected pace. Displacement of the pelvic floor relative to the bony pelvis was calculated using double integration of the accelerometer data. Vibrational damping coefficients were calculated using a wavelet-based approach to determine the effect of continence status, parity, running speed and time on vibrational damping.

Findings: Seventeen women (n = 10 reported regularly leaking urine while exercising, while n = 7 reported not leaking) completed the running protocol. No differences in vibrational damping were detected between continent and incontinent women when all frequency bands were evaluated together, however significant effects of parity, time, running speed and continence status were found within specific frequency bands. Parous women demonstrated less damping in the 25-40 Hz band compared to nulliparae, damping in the 13-16 Hz band was lower after the 30-min run, and incontinent women demonstrated lower damping in the 4.5-5.5 Hz band than continent women when running at 7 km/h.

Interpretation: Intra-vaginal vibrational damping may be useful in detecting biomechanical mechanisms associated with pelvic floor disorders experienced by females during exercise.

Keywords: Accelerometry; Pelvic floor disorders; Running; Stress urinary incontinence; Vibrational damping.

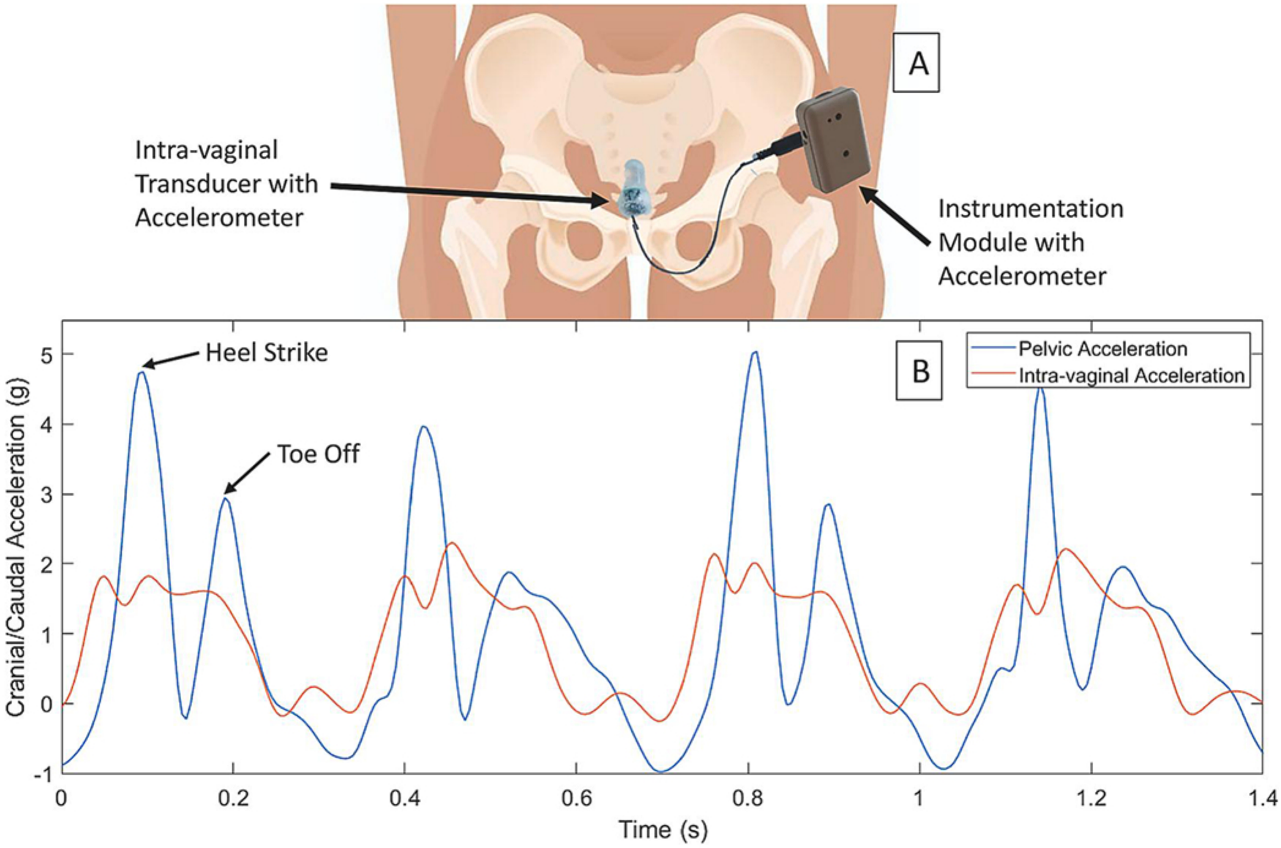

Figure 1. Experimental setup and data (A) Instrumentation Module is placed on the mid left iliac crest and the intra-vaginal transducer is placed in the posterior fornix of the vagina. (B) Example accelerometer data collected during a 10 km/h run with heel strike and toe off identified.

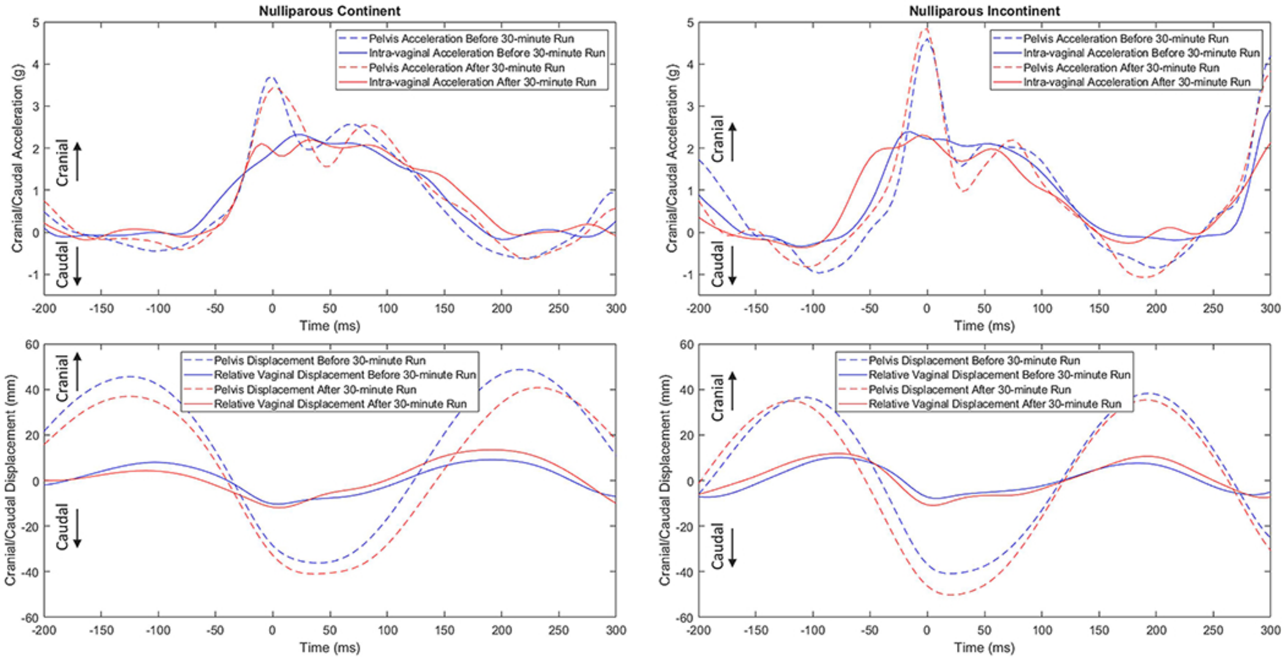

Figure 2. Representative data from a nulliparous continent female (left) and a nulliparous incontinent female (right) while running at 10 km/h before (blue) and after (red) the 30-minute run. The top figures show the cranio-caudal pelvic acceleration (dashed) and intra-vaginal (IVT) acceleration (solid). Note the increase in oscillations when comparing intra-vaginal accelerations at heel strike before and after the 30-minute run (solid blue vs solid red lines on the upper graphs). The bottom figures show the cranio-caudal pelvis displacement (dashed) and IVT displacement relative to the pelvic displacement (solid).

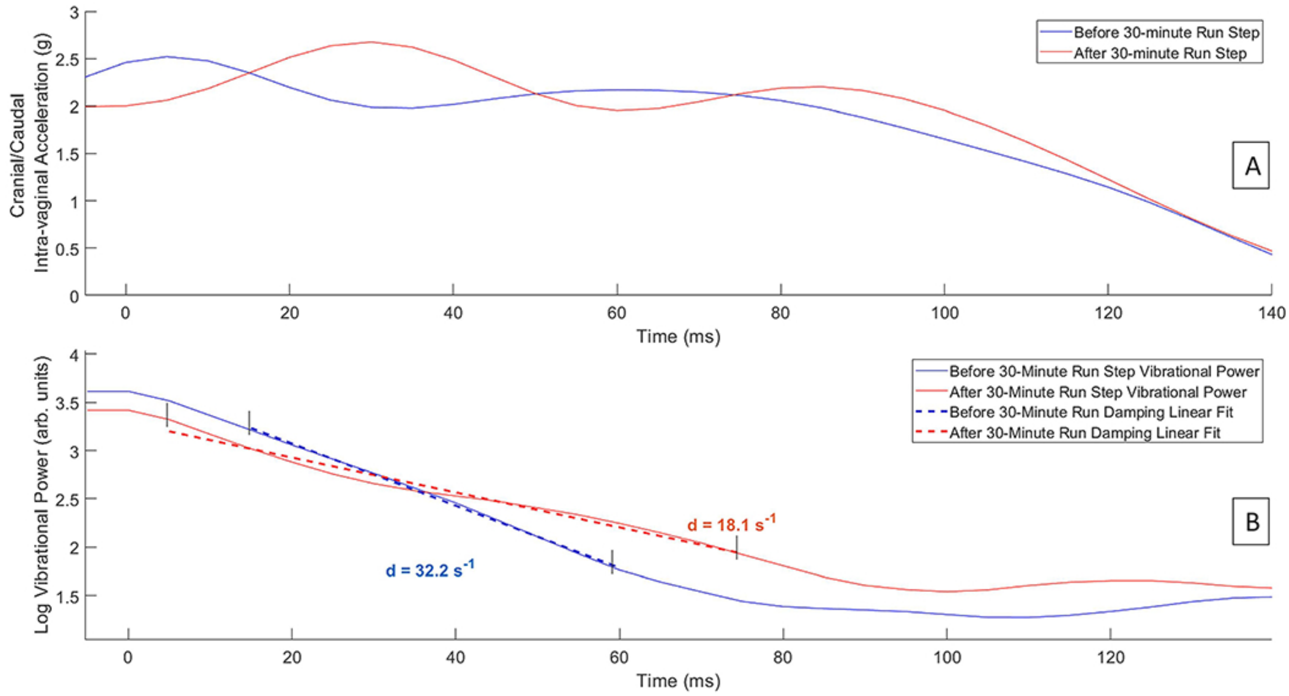

Figure 3. Damping coefficient calculation example. (A) Acceleration data from two representative steps from a single incontinent nulliparous woman before (blue) and after (red) the 30-minute run while running at 10 km/h. Time is normalized so that heel strike, as measured by maximum acceleration at the pelvis (not shown), occurs at 0 ms. (B) Damping coefficient calculation using a continuous wavelet bank transformation. Acceleration measurements were transformed by each individual wavelet in the wavelet bank then summed to calculate the total vibrational power. slope of the logarithmic vibrational power decay was used for calculating damping coefficients. The dashed lines indicate the linear fit from the point of steepest slope, indicated by a solid vertical line, to the point where the power was 25% of the first point, indicated by a second solid vertical line. The slope of the linear fit, was the damping coefficient for the step, shown as d.

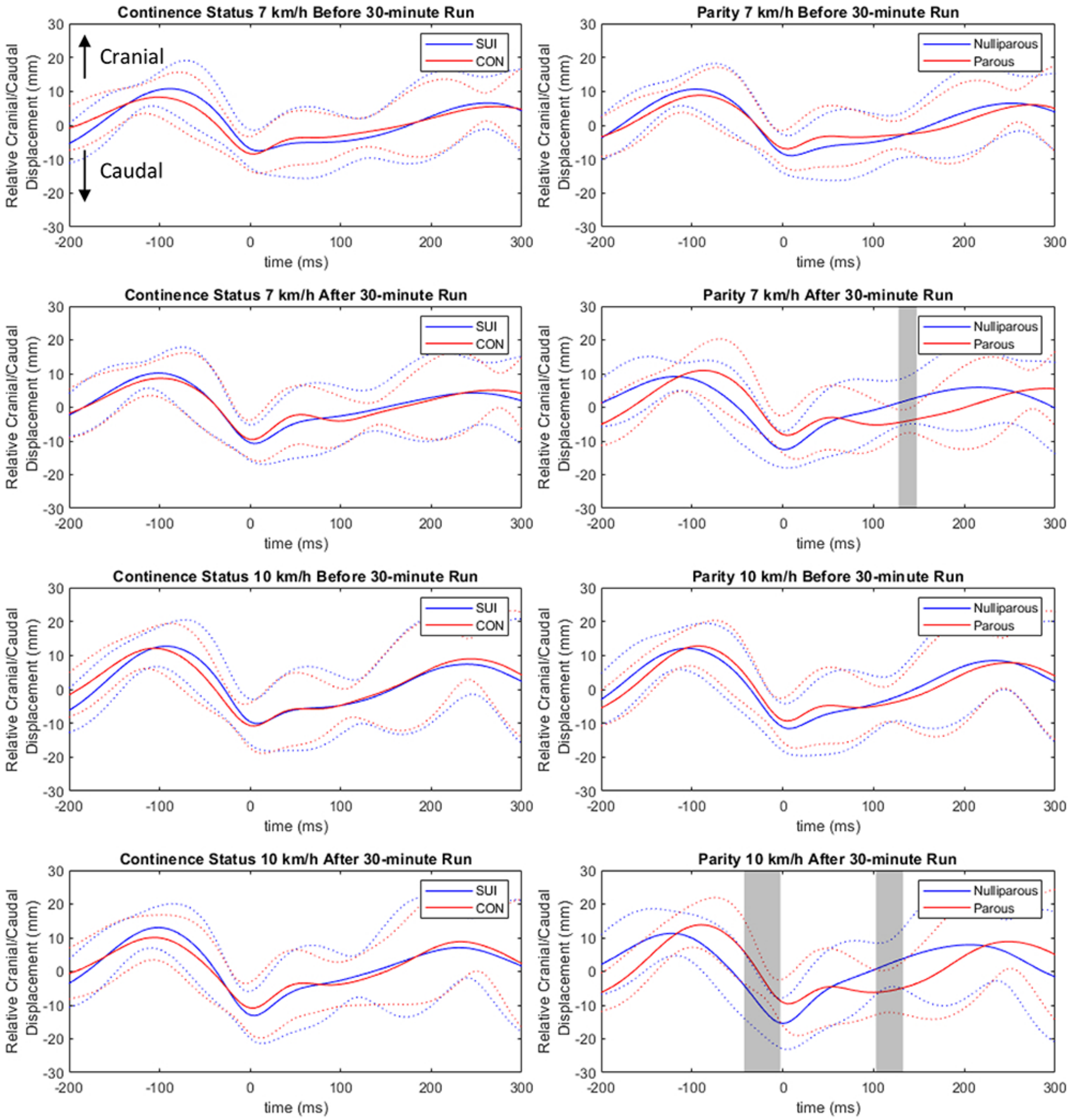

Figure 4. Relative intra-vaginal sensor displacement in the cranial (positive displacement) and caudal (negative displacement) directions at different running speeds. The left figures show relative displacement for continent and incontinent women and the right figures show relative displacement for nulliparous and parous women. Solid lines are the group means, and dotted lines denote the upper and lower 95% confidence intervals for the groups. Areas shaded gray are time periods where the relative displacement was significantly different (deviation-test and α=0.05), which only occurred between the nulliparous and parous groups.