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DEVELOPMENT AND TESTING OF A NOVEL ELECTRODE FOR RECORDING ELECTROMYOGRAPHY DATA FROM THE PELVIC FLOOR MUSCLES

Hypothesis / aims of study

The purpose of this study was to compare the reliability, susceptibility to motion artefact and susceptibility to crosstalk of surface electromyography (EMG) data recorded from the pelvic floor muscles (PFMs) using a novel electrode design and using a commercially available electrode (Femiscan™) probe. It was expected that the novel electrode would be equally reliable as the Femiscan™ electrode, but that it would be less susceptible to motion artefact and crosstalk.

Study design, materials and methods

The novel electrode is presented in Figure 1. This electrode was developed to overcome several limitations of traditional electrodes used to record EMG from the PFMs, including large surface areas that result in an increased likelihood of recording crosstalk, incorrect electrode configurations that either combine or subtract data from the left and right PFMs and motion between the vaginal wall and the electrode that increases the likelihood of motion artefact contamination.

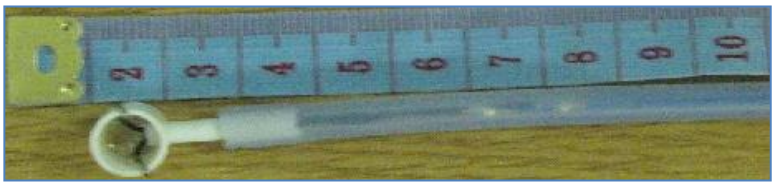

Figure 1: The novel electrode used in this study. Using a gloved finger, the differential electrode is placed the correct position and orientation (electrodes located along the line of action of the muscle fibers) and suction is used to hold the electrode in place on the vaginal wall.

Twenty healthy women between the ages of 18 and 50 participated on two occasions separated by approximately one week. On each occasion, the women performed three repetitions of a series of tasks with each electrode in situ. The order of the electrodes was randomly assigned, and the Femiscan™ electrode was custom modified such that separate differential channels recorded EMG signals from each side of the PFMs. Maximum voluntary contractions (MVCs) of the PFMs were used to determine the reliability of EMG amplitudes between trials and between days. Maximal effort coughs were performed in order to determine the susceptibility of each electrode to recording motion artefact. Unilateral hip adductor and external rotator contractions were performed at increasing effort levels (25%, 50% and 100% MVC). These tasks were performed while the participants attempted to keep their PFMs relaxed and while they attempted to maximally activate their PFMs to help elucidate the susceptibility of the different electrodes to crosstalk from the hip adductor and external rotator muscles.

Intraclass correlation coefficients ($ICC_{(3,1)}$) and coefficients of variation (CVs) were used to determine between-trial reliability and $ICC_{(3,3)}$, normalized mean absolute differences (MADs) and standard error of the measurement (SEM) were used to determine between-day reliability.

Motion artefact was identified by computing the power spectrum of each EMG data file recorded during maximal effort coughing. When the peak power in the 1-20Hz bandwidth exceeded the mean power in the 20-450 Hz bandwidth, then motion artefact contamination was deemed to be present. The proportion of files contaminated with motion artefact was compared between electrodes using a t-test.

Crosstalk was assessed separately using the peak EMG activation recorded during each task (hip adduction/ hip external rotation) and under each condition (PFMs relaxed, PFMs maximally activated). Repeated-measures analyses of variance were used to compare changes in EMG amplitude across contraction intensity between electrodes.

A small subset of participants (n=4) performed a secondary study to determine whether either electrode was recording crosstalk from the transverses abdominus muscle. The peak and time lags of the cross-correlation functions between signals recorded from the transverses abdominus muscle (using fine wire electrodes) and PFMs (using both the Femiscan™ and the novel electrode) were determined.

Results

Between trial reliability was excellent for both electrodes ($ICC_{(3,1)}$ = 0.964-0.974 for the novel electrode vs 0.943-0.974 for the Femiscan™ electrode; CV 8.6% for the novel electrode vs 11.2% for the Femiscan™ electrode). Both vaginal electrodes were less reliable between days ($ICC_{(3,3)}$ = 0.648-0.715 for the novel electrode vs 0.788-0.924 for the Femiscan™ electrode; normalized MAD 45.5-67.0% for the novel electrode vs 21.5-38.8% for the Femiscan™; SEM 17.5-18.7µV for the novel electrode, 8.8-14.1µv for the Femiscan™). There were no significant differences in reliability between the electrodes.

There was no difference between electrodes in terms of the number of files contaminated by motion artefact. Using the novel electrode, 28.0% of files had identifiable motion artefact whereas using the Femiscan™ electrode, 32.1% of files had motion artefact ($p=0.225$).

At submaximal intensities of ipsilateral hip muscle adductor and external rotator contractions, the novel electrode did not record significantly higher amounts of PFM EMG activity than it did when the hip was relaxed, whereas the Femiscan™ electrode did recorded significantly higher PFM EMG activity when the hip muscles were contracted submaximally compared to when the hip muscles were relaxed.

There were low cross-correlation coefficients ($r<0.90$) and consistently large time lags ($t>0.5$ms) between transverses abdominus and PFM EMG channels for both electrodes.

Interpretation of results

The novel electrode was as reliable as the Femiscan™ electrode. This result is promising given that the small electrode surfaces on the novel electrode would theoretically have a negative impact on between-day reliability. The novel electrode did not result in significant improvements in motion artefact contamination. For this reason, we have redesigned the electrode to incorporate recessed electrodes and are currently assessing the impact of the new electrode design on motion artefact (See Figure 2).

The fact that the novel electrode did not demonstrate increases in PFM EMG activation during submaximal hip muscle contractions but that the Femiscan™ electrode did suggests that the novel electrode is less susceptible to crosstalk contamination from the hip musculature than the Femiscan™ electrode. The outcome of the cross-correlation analysis of the EMG data recorded simultaneously from the transverses abdominus and the PFMs suggests that neither of the electrodes recorded crosstalk from the transverses abdominus muscle.

Concluding message

The novel electrode designed in our laboratory for use in studies of PFM function are as reliable as the Femiscan™ electrode, and better able to isolate EMG activity generated by the PFMs. This makes our novel electrode superior for use during studies of PFM function particularly when participants are contracting their hip musculature.

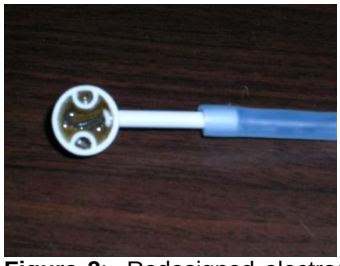

Figure 2: Redesigned electrode currently undergoing evaluation. The stainless steel electrodes are now housed such that they are approximately 1mm from the electrode surface. Conductive paste is injected into the recessed cavities that house the electrodes. Suction is still used to hold the electrode in place on the vaginal wall.

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What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**Queen's University and Allied Hospitals Health Sciences Research Ethics Board**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**