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Concentric Needle Quantitative EMG of Pubovisceralis Muscle Group: Normative Data from Asymptomatic Nulliparous Women

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Abstract

Objectives—The muscles of the pelvic floor closest to the vaginal opening are subject to the greatest degree of stretch during vaginal childbirth. We aim to define normative quantitative EMG (QEMG) parameters for the pubovisceralis (PV) muscle in nulliparous women, and compare them to the external anal sphincter (EAS).

Methods—In 31 asymptomatic nulliparous women, concentric Needle EMG of the PV and the EAS was performed. Multi-motor unit action potential (Multi-MUAP) and interference pattern (IP) algorithms were utilized to obtain QEMG parameters. We used paired t-tests to compare PV and EAS parameters.

Results—The motor units for the PV were of greater duration ($p < 0.002$) and had more turns ($p = 0.03$) than the paired motor units in the EAS. The EAS demonstrated more turns/second ($p = 0.02$), greater activity ($p = 0.01$), and more short segments ($p = 0.009$) than the PV.

Conclusions—The PV has longer and more complex motor units than the EAS. This knowledge continues to improve our ability to detect neuropathic changes in this vulnerable muscle area following childbirth or in women with pelvic floor dysfunction. In addition, the PV muscle group appears less responsive to requests for increased neuromuscular activity than the EAS. This needs to be further evaluated, as it may be associated with understanding which portion of the muscle functionally shortens to maintain the closure of the levator hiatus.

Introduction

The muscles of the pelvic floor closest to the vaginal opening are subject to the greatest degree of stretch during vaginal childbirth.¹ This stretch can lead to both muscle and nerve injury, with subsequent development of pelvic floor disorders.^{2–6} Quantitative neurophysiologic techniques can be used to document this injury and repair.^{7, 8} Only one previous manuscript has delineated normative data for the levator ani, but those data were for deeper muscles within 1 cm of the ischial spine.⁹ We have noticed audible differences in the electromyographic (EMG) signals between the external anal sphincter (EAS) and the more distal pubovisceralis muscles we evaluate. We aim to define normative quantitative EMG parameters for the pubovisceralis muscle in nulliparous women, and compare them to the EAS.

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Materials and Methods

We studied the first 31 asymptomatic women enrolled in an ongoing IRB-approved, prospective study evaluating the effect that pregnancy and childbirth have on the pelvic floor nerves and muscles using concentric needle electromyography (EMG). Using an index finger just inside the vaginal introitus, the distal pubovisceralis muscles were pinched between the thumb and index finger. Separately for the right and left sides, approximately 1.5 cm below its insertion into the pubic bone, we inserted a 37 mm concentric needle electrode transvaginally until crisp EMG motor unit activity was heard. This same process was repeated for the external anal sphincter as previously described.¹⁰⁻¹²

We recorded the EMG signal directly onto the Alpine Biomed Keypoint EMG system (Alpine Biomed, Fountain Valley, CA) equipped with the NET software package. Bandpass filters were set at 5Hz – 10 kHz. Gain was 0.1-0.5 mv/div; sweep speed was 10ms/div. The concentric needle was then sequentially moved approximately 5 mm in a standardized fashion 3-4 times (distal to proximal, perpendicular to muscle fibers) to sample unique motor unit territories. After insertion, and following each movement of the needle, the muscle activity was allowed to return to baseline (tonic activity). Prior to each subsequent relocation of the needle, we asked the subject to squeeze the pelvic floor muscles as tightly as possible to generate an interference pattern. A new recording was created for each territory to avoid repeat sampling.

For each recording (unique sampling site), we used the multi-MUAP algorithm to select and identify motor units. Selected, but poorly-defined, motor units with severely unstable baselines were discarded. Duplicated motor units were combined with one another. Quantitative parameters (duration, amplitude, area, area/amplitude, size index, phases and turns) were automatically calculated by the software.^{13, 14} Occasionally, for clearly visible MUAPs, the cursor placement for duration (denoting the onset or completion of the action potential) was deemed inappropriate (usually associated with high baseline muscle activity). For those rare MUAPs, using the rastered as well as superimposed sample of identified exemplars (0.1 mv/division), the cursors were repositioned.

For each recording area, an Interference Pattern (IP) analysis was also performed. At baseline muscle activity, and at best squeeze, an epoch of 500 ms was selected, and quantitative IP parameters assigned (turns/second, amplitude/turn, number of short segments, activity, and envelope).^{15, 16} With each epoch sampling, an X-Y plot of Turns vs Amplitude, Activity vs. NSS, and Activity vs. Envelope would refresh on the computer screen.

Despite coaching, many subjects found it difficult to generate profound changes in the EMG signal that most experienced neurophysiologists would recognize as a “full” interference pattern. Although simultaneous pressure readings were not performed, we observed that when activity levels were greater than 20%, we could clearly detect muscle position change, and notice an audible difference in the EMG signal. For this purpose, we therefore defined an “effective squeeze” as one in which activity was greater than 20% (Figure 1). We then compared IP parameter means between muscles in resting and “effective squeeze” states.

For each muscle and for each parameter, pooled means, standard deviations and 95% confidence intervals were tabulated. We used a Kolmogorov-Smirnov test to evaluate normal distributions. Means between the muscles were compared by first obtaining overall subject means for each parameter and then utilizing paired t-tests.

Results

The study subjects were 31 (SD 4) years old with a BMI of 24.6 (SD 6) kg/m². Ninety-one percent were Caucasian. For the pubovisceralis and EAS muscles respectively, 765 (25 per

subject) and 770 (25 per subject) MUAPs were sampled for this data set. The Kolmogorov-Smirnov Test demonstrated only Size Index to be normally distributed in both the PV and EAS muscles. The relevant data for each muscle and parameter are shown in Table I. The motor units for the pubovisceralis group were of greater duration ($p < 0.002$) and had more turns ($p = 0.03$) than the paired motor units in the EAS (Figure 2). We sampled 510 (27% were “effective squeeze”) and 454 (35% were “effective squeeze”) IP epochs in the pubovisceralis and EAS muscles respectively. The EAS demonstrated more turns/second ($p = 0.02$), greater activity ($p = 0.01$), and more short segments ($p = 0.009$) than the pubovisceralis muscle. These differences were seen in the “effective squeeze” subset, but not in the resting subset (Table II).

Discussion

This is a continuation of the effort to standardize and define normative neurophysiologic data for the pelvic floor so as to better detect changes associated with childbirth as well as pelvic floor dysfunction.^{10-12, 17} We have demonstrated that many quantitative EMG parameters are substantially different between the EAS and the pubovisceralis muscles and therefore need their own unique normative data.

As Weidner⁹ saw in the more proximal portion of the levator ani complex, we found that the pubovisceralis muscle has longer and more complex motor units than external sphincter. Some of the first MUAP changes seen with reinnervation repair processes are a result of so-called temporal dispersion. As new relatively unmyelinated axons grow toward denervated muscle fibers, the conduction velocity is slower. This can lead to both a prolongation of the MUAP duration, and a separation of the summated muscle fiber action potentials detected by the needle electrode, generating increased complexity of the action potential waveform (more turns).¹⁴ Knowing the size and complexity of motor units for the pubovisceralis muscles will assure our ability to detect neuropathic changes following childbirth or with dysfunction appropriately (and not assign that diagnosis simply by virtue of the inherent differences between it and the EAS).

Interestingly, in our data, the Interference Pattern parameters for EAS show a higher level of EMG activity than the pubovisceralis: increased turns/second, increased number of short segments, increased activity. Because the IP parameter means are values derived from a combination of both resting (moderate tonically contracting) muscle activity and best squeeze muscle activity, we were curious whether the differences were due to increased resting or squeeze activity. There were no differences at resting tone, but noticeable differences with “effective squeeze”, suggesting a better response to the request for recruitment of new motor units. Although we were unable to analyze this objectively, we noticed that in many subjects the most distal pubovisceralis muscles (first 1-2 samples recorded during the standardized superficial to deep evaluation of the muscle) were less likely to develop an increased interference pattern during squeeze efforts, whereas the deeper portion (1.5-2 cm) was more likely to respond. This needs to be further evaluated, as it may be associated with understanding which portion of the muscle functionally shortens to maintain the closure of the levator hiatus.

It is important to recognize that every effort to adhere to a standardized protocol remains important when comparing data. Different manufacturer's algorithms,¹⁸ use of previous software from the same manufacturer¹⁰, and subtle differences in sampling or selection of MUAPs (Podnar, personal communication) might affect the data. In summary, we continue to characterize the clinically useful quantitative electrophysiologic parameters for various pelvic floor muscles associated with maintenance of continence and support.

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Figure 1.

A single subject's scatterplot of activity (percent of 500 ms epoch that is filled with detectable EMG signal) vs NSS (number of short segments). A) Not effective squeeze because little change in activity despite request to contract muscle. B) Effective squeeze. Dots in upper right quadrant represent significant increase in activity (as well as NSS) with muscle contraction.

Figure 2.

Motor Unit Action Potentials from the pubovisceralis (labelled puborectalis) and sphincter ani of a single subject are depicted. The visible discrimination between the two can be very subtle, which is why quantitative EMG algorithms are so useful. The most striking feature in this subject is the longer duration, and greater number of turns. Most subjects had differences which were more subtle than this.

Table 1
Means and Confidence Intervals for Motor Unit Action Potentials (MUAP) and Interference Pattern (IP) Parameters for Pubovisceralis (PV) and External Anal Sphincter (EAS) Muscles

MUAP	Mean	SD	PV			Mean	SD	EAS			p
			5%ile	95%ile				5%ile	95%ile		
Amplitude (mcv)	412	283	121	940		379	294	116	922		0.2
Duration (ms)	6.2	2.9	2.4	11.2		5.1	2.6	1.8	10.1		0.002
Area (mcv*ms)	326	254	68	817		248	240	57	700		0.009
Area/Amp	0.82	0.4	0.35	1.53		0.66	0.3	0.31	1.29		0.001
Size Index	-0.12	0.6	-1.19	0.95		-0.37	0.6	-1.3	0.79		0.002
Phases (n)	3.1	1.4	2	6		3.1	1.4	2	6		0.3
Turns (n)	2.8	1.6	1	7		2.5	1.6	1	6		0.03
IP											
Turns/Second (n)	319	217	43	732		374	262	40	835		0.02
Amp/Turn (mcv)	331	139	177	604		319	108	182	517		0.5
NSS (n)	189	179	12	558		234	221	10	669		0.01
Activity (%)	14.5	14	0.69	42.1		18	17	0.6	52.6		0.009
Envelope (mcv)	809	631	163	2057		883	703	177	2521		0.06

p = paired t-test (PR vs. EAS) using paired subject means

Table II

Comparison of IP Parameters During “Effective Squeeze”

Parameter	PR	EAS		p
		Mean	SD	
Turns/Second	610	153	676	164 0.001
Amp/Turn	442	154	403	103 0.05
NSS	431	159	484	179 0.006
Activity %	34	11	38.2	12.9 0.007
Envelope	1457	753	1505	771 0.9

SD = Standard Deviation

P = paired t test (PR vs EAS) using paired subject means