EMG Evaluation and Interpretation

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Electromyography (EMG)*:* is the recording of electrical potentials generated by the depolarization of muscle fiber membranes (Bo 2017)
Includes surface EMG and needle EMG

Surface electromyography (sEMG): is a recording of motor unit action potentials using surface electrodes placed on the skin or mucosa close to the muscle of interest. (Vodusek 2015)
Assessment of the activation pattern or behaviour of the PFM
Includes vaginal, rectal and skin of the perineum

Psychometrics of EMG testing

- Interrater reliability (Grape 2009)
- Intraobserver reproducibility (Sigursardottir 2009)
- Test retest reliability on the same day - fair to high (Auchincloss 2009)
- Test retest reliability between days - poor (Brown 2008, Auchincloss 2009)
- EMG of the PFM has statistically significant predictive validity for undifferentiated UI – lower EMG values in patients with UI (Glazer 1999, Potach 2006).

Many variables affect EMG amplitude, quality and reliability (Vigotsky 2015, Disselhorst-Klug 2009, Enoka 2015, Clancy 2015)

- Placement of electrodes
- Property of electrodes
- Patient characteristics including
    - Skin impedance
    - Adipose tissue
    - Hair
    - Rectal / vaginal lubrication
- EMG device specifics
- Skill of the operator
- Number of firing motor units
- Muscle fatigue and length tension

Normalization of the amplitude: the value obtained during a specific task as a percent relative to the electrical activity detected during a MVC (Disselhorst-Klug 2009).
Power spectrum: the distribution of frequency components of the sEMG signals, measured in Hz (Clancy 2015).

It may not be reliable to compare data

- From patient to patient
- From day to day
- Unless you are working with normalized data

Standardize for each patient
  - Equipment
  - Therapist
  - Electrode placement
  - Testing protocol
- Document all variables
- Quality set up of electrodes and EMG

EMG measures the active component of muscle tone and must be combined with other PFM assessment (palpation and ultrasound) for a complete assessment of muscle function.
EMG is not used in isolation

Evaluation measurements
- Many different protocols, no studies
- Resting measures and contractile measures
- Therapist's preference
- Remember learning occurs during the evaluation

AN INTERNATIONAL CONTINENCE SOCIETY (ICS) REPORT ON THE TERMINOLOGY FOR PELVIC FLOOR MUSCLE ASSESSMENT
Helena Frawley, Beth Shelly, Melanie Morin
Prepublication

Muscle tone

Tone exists on a continuum, from low tone to high tone. Tone is a dynamic physiological state modulated by many inputs: spinal cord, cortex, brainstem relays, stretch reflexes and cutaneous receptors, visceromotor reflex pathways, emotions and pain (anticipation or experience of pain).

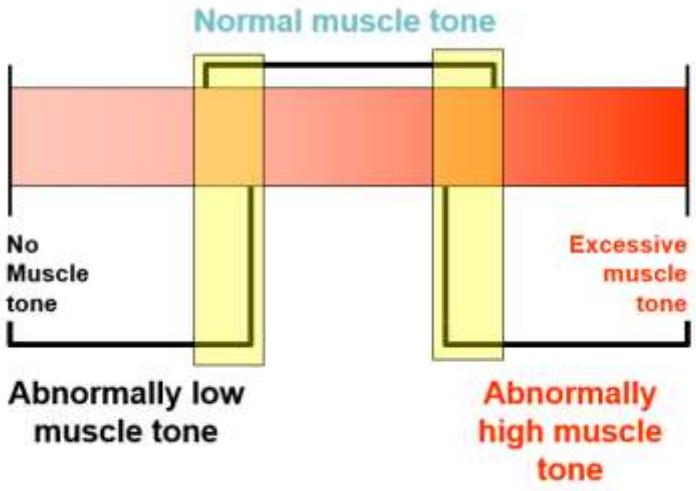

Figure 2: Spectrum of muscle tone (adapted from Allen & Widener 2009)

Muscle tone has two components:
- Contractile
- Non-contractile (passive)

Contractile component

- Created by the activation of motor units
- EMG activity

Non-contractile viscoelastic, or biomechanical component

- Independent of neural activity (not captured by EMG)
- Reflects the passive physical properties of the viscoelastic tension of
    - muscle tissues (e.g. the extensibility of actin-myosin cross-bridges)
    - non-contractile cytoskeleton proteins and connective tissues surrounding the entire muscle (epimysium)
    - muscle fascicle (perimysium)
    - muscle fiber (endomysium)
    - osmotic pressure of the cells

Definitions and descriptions of tone in a patient with neurological disorder

Hypotonicity: a decrease in muscle tone in a patient **with** a neurological disorder. It may be due to a lower motor neuron or a muscle disorder. The term flaccidity is often used interchangeably.

Hypertonicity: an increase in muscle tone in a patient **with** a neurological disorder. It may be due to an upper motor neuron or extrapyramidal lesion, which in turn may lead to spasticity or rigidity

Dystonia: a disorder characterized by abnormalities of muscle tone and movements/postures in a patient **with** a neurological disorder. It is often due to damage to the basal ganglia or other brain regions that control movement.

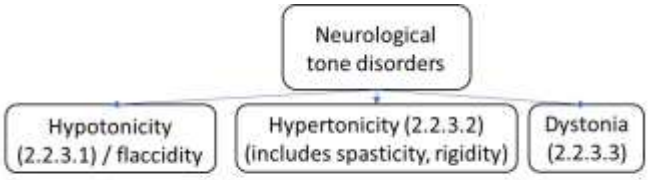

Figure 3a Terms for disorders of tone due to a neurological disorder

Definitions and descriptions of tone in a patient without neurological disorder

Decreased PFM tone: a decrease in resting muscle tone in a patient **without** a neurological condition

Increased PFM tone: an increase in muscle resting tone in a patient **without** a neurological disorder. Increased tone may occur without patient report of pain.

Transient increased muscle tone: Increased muscle tone that decreases with verbal instruction, re-assurance or gentle pressure**.** Transient increase in tone may occur at any time during the examination.

Muscle spasm: persistent contraction of muscle that cannot be reduced voluntarily (Bo 2017, Doggweiler 2017). Spasms may occur at irregular intervals with variable frequency and extent, and over time may lead to increased viscoelastic stiffness and shortening in the muscular and connective tissues

Terms such as short or elevated PFM may not be discernible via digital palpation and are therefore not recommended as sign terms

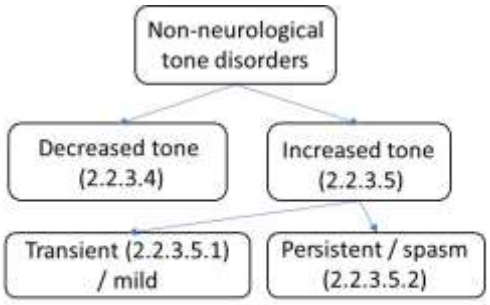

Figure 3b Terms for disorders of tone due to a non-neurological disorder

Palpation versus EMG - contractile and non contractile tissues

EMG	Palpation	Possible cause
Increased uV	Soft muscle	Artifact
Increased uV	Hard muscle that relaxes easily with pressure and verbal cues	Transient increased muscle tone
Increased uV	Hard muscle that does not relaxes easily with pressure and verbal cues	Increased PFM tone Muscle spasm Over-activity in the PFM
Normal uV	Soft muscle	Normal PFM
Normal uV	Hard muscle	Increased PFM tone Non contractile component

Resting measures

Baseline muscle activity: the amount of microvolts generated by activation of motor units in the target muscle during rest (Bo 2017, Castro 2017)

The recording of resting activity is highly susceptible to contamination by ambient noise. A low proportion of noise in the signal (or higher signal-to-noise ratio) is necessary for accurate assessment.

Unlike many other skeletal muscles(, the PFMs are thought to have a level of constant EMG activity in order to maintain continence and support of pelvic/abdominal contents.

Inconsistent resting baseline: the variation of baseline between contractions, between sets, or between days (Bo 2017, Castro 2017)

Elevated resting activity: an increase in the active component of muscle tone; (the passive/viscoelastic component is not captured by sEMG).

Overactivity in the PFM: an increased in contractile component of tone characterized by inconsistent resting baseline, elevated resting baseline and slow de-recruitment. Overactivity in the PFM is not a diagnosis but only one part of the muscle dysfunction 2/3 of dysfunctional muscles will have normal resting baseline (Cram 1998)

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Resting baseline

- 1 to 2 minutes
- Normal resting tone
  - Baseline fairly constant without large spikes between contractions and between sessions
  - There is no uV level below which normal resting tone occurs (Potach 2006)
  - Consistently elevated microvolt levels without expected symptoms may not be a PFM dysfunction
- EMG assessment must be taken in context with other examination findings
- Artificially low (flat) or high and erratic baseline may be bridging or increased skin impedance
- It may be necessary to perform the anal wink reflex test with EMG on if there is no voluntary PFM contraction
- Consider rechecking resting baseline between tests

Contractile measures

Signal amplitude: microvolts (μV) a muscle generates (Bo 2017).

Increase sEMG amplitude is

- Recruitment of motor units
- Increased firing rate (Farina 2016)

Increase sEMG is not

- A direct force measurement / strength
- Relationship between force and EMG is not linear and is affected by
  - type of contraction (concentric/isometric/eccentric)
  - speed of contraction.

During strength training

- Early gains in force / strength are related to
  - an increase in motor unit recruitment
  - higher frequency
  - higher signal amplitude
- Later gains in strength / muscle hypertrophy (Bo 2017) are not reflected in increased sEMG amplitude

Peak amplitude: the highest sEMG amplitude achieved measured in microvolts (Bo 2017, Castro 2017)

Time to peak muscle activation: time in ms or s from onset of muscle activity to peak activity.

Rate of change: the mean slope of the ascending curve in μVs during a fast MVC**.**

Slow recruitment: a longer time to peak muscle activation in s or a slower rate of change Brueckner 2018).

Slow recruitment could be a sign of PFM dysfunction if it leads to leakage during coughing and sneezing when a quick muscle contraction is needed to counteract increased intra-abdominal pressure (Bo 2017, Castro 2017).

Reaction time: the latency (time in ms) between a stimulus (or the command) and the onset of muscle activation (Dewaele 2018).
Time from command to peak: time in ms from stimulus to peak activity. This term encompasses both the reaction time and the time to peak muscle activation.
Slow reaction time: a longer time to initiate muscle activation.

Time to return to baseline muscle activity: time in s from peak activity to resting activity.
Rate of change: the mean slope of the descending curve in uV/s during a fast MVC**.**
Slow de-recruitment: slow relaxation of the muscle contraction (Bo 2017)

Rate of change of amplitude during sustained contraction: the change in sEMG amplitude divided by the duration of the contraction: $EMG_{final} - EMG_{initial}$/time(s) (McCrary 2017).. The contraction could be sustained or intermittent at different % of MVC (McCrary 2017).. A higher rate of change will be indicative of lower endurance.

Timing of muscle activity: onset of the activation in milliseconds can be assessed in relation to onset of activation in other muscles, provocative activities or other aspects of a task.

- normal
- delayed: delayed activation of the PFM relative to the onset of a cough or a postural perturbation has been found in women with stress urinary incontinence (Moser 2018)

Duration of a sustained contraction: the duration in seconds that a contraction could be sustained at a specific % of MVC (McCrary 2017).
A shorter duration suggests lower endurance

PFM contraction and relaxation

- Confirm PFM contraction technique
  - Palpate the end of the sensor during a PFM contraction
  - Sensor should move inward and may deflect slightly downward toward the table
  - With very weak PFM, there may not be palpable movement
  - There should not be any movement toward the feet (bearing down)
  - Observe the patient for accessory muscle activity, movement, breath holding
- Holding:
  - 5 or 10 second contraction
  - 10 second relaxation
  - 10 repetitions
- Quick:
  - 1 to 3 second work
  - 3 to 5 second relaxation
  - 6 to 10 repetitions
- Endurance test
  - Sub max long hold
  - Hold contraction up to 2 minutes
  - Record length of time the patient is able to stay above the 50% line
  - Very important in external anal sphincter weakness

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