Whitepaper: EMG Registration for Pelvic Floor Muscles

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Introduction

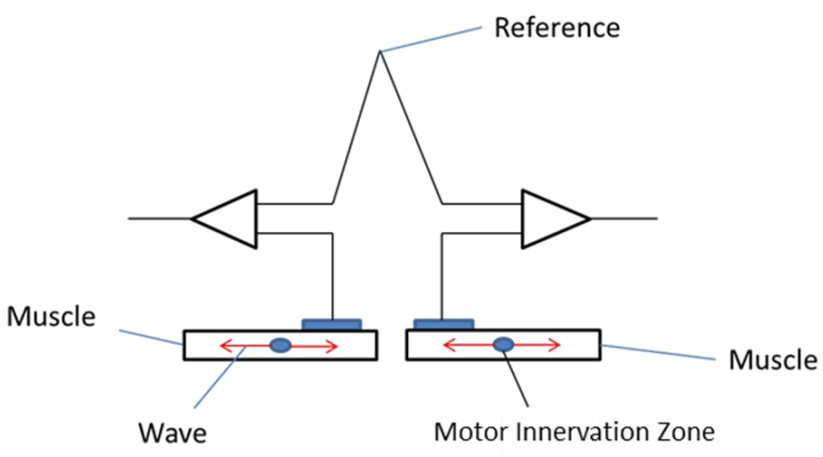
Electromyography (EMG) is a useful and objective tool to obtain information about the muscle activity(1). A muscle consists of muscle fibres. The ends of the efferent nerves are connected to the muscle fibres through motor units. Every single motor unit serves several muscle fibres. An electrical impulse, traveling through the nerves and motor units, cause a depolarisation (contraction) and repolarisation (return to their original state) of the muscle fibres. This is called a muscle action potential. This can be detected with surface electrodes, which show a composite signal of the global EMG activity of many muscle fibres in the specific muscle.

The quality of the EMG activity signal is dependent on many variables. The most important are: the configuration used for detection, the positioning of the electrodes with respect to the muscles of interest and the size of the electrode(1)(2)(3).

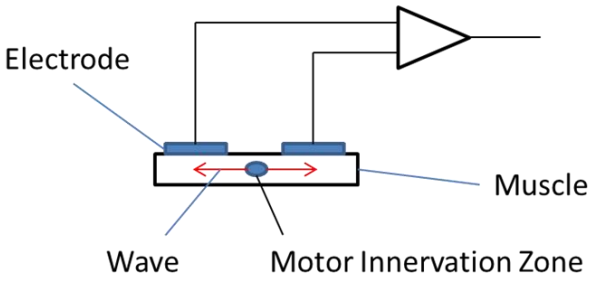
EMG configuration

There are two configurations widely used for the detection of EMG activity: Unipolar electrode configuration (see Figure 1a) and bipolar or differential electrode configuration (see Figure 1b-c). In unipolar an active electrode is placed over the muscle of interest and a reference electrode is placed at an electrically neutral site (most of the times a bony part of the body). Also a reference signal can be used instead of the reference electrode. Both the active and reference are connected to an amplifier to detect the EMG activity. In a bipolar configuration both electrodes are active and placed over the muscle of interest. Both are connected to an amplifier and the detected EMG activity is the difference of the potential measured between the two electrodes (also called a differential signal). Bipolar recordings will vary with extrinsic factors such as the shape and length of the muscles and therefore it is not valid to compare the EMG pattern from one individual to another or one muscle group to another(1). Furthermore it is not valid to use the bipolar

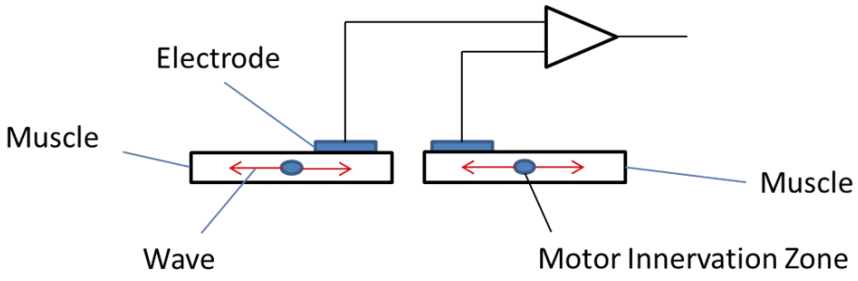
configuration over multiple muscles (so placing one electrode at one muscle and the other electrode at another muscle, see also see Figure 1c).
The unipolar configuration does not have these significant limitations. So for unipolar recordings it is valid to make a comparison between different muscles and different individuals(1).



a) Unipolar over multiple muscles



b) Bipolar over one muscle



c) Bipolar over multiple muscles

Figure 1: Electrode configurations

Position of electrode

For both configurations it is important to place the active electrode(s) as close to the muscle of interest as possible. In bipolar configuration it is furthermore important to place the electrode in line with the direction of the muscle fibres. Furthermore, a bipolar configuration is only valid if it is used over one single muscle. If the two electrodes are placed at different muscles or muscles sides, the resulting recording cannot be seen as valid EMG activity of either of the muscles or as a valid average EMG activity of these muscles.

To perform reliable repetitive measurements it is furthermore important that the electrodes are (re-) positioned at the same location with respect to the muscle.

Electrode size

The size of the electrode also influences the quality of the signal. The larger the electrode surface, the more sensitive it is for cross-talk from surrounding muscles, which could lead to misinterpretation of the presented EMG activity(2)(2).

EMG for pelvic floor muscles

In pelvic floor therapy EMG is used to evaluate the neuromuscular function of the pelvic floor muscles (PFM) and to provide biofeedback during strength or coordination training(2). This is mostly done with an intravaginal or intra-anal probe with surface electrodes for the registrations. The probes vary in size and shape. In literature it was found that, the larger the recording probe, the larger the output force of the PFM. This suggests that the PFM react to the presence of a (large) probe. An optimal recording device should be as least invasive as possible to overcome this limitation(9).

To use the EMG activity as a clinical outcome, predictor or measure of success or progress, the measurement needs to be reliable and valid. Reliability is confirmed with good test-retest between trials or even better between days and intra- and inter-rater reliability. Validity is the degree to which evidence and theory support the interpretations of the measurements. Mostly, this is done by using other validated

measurement tools to confirm the findings. Commonly used tools are ultrasound and MRI. The relationship between reliability and validity is shown in Figure 2.

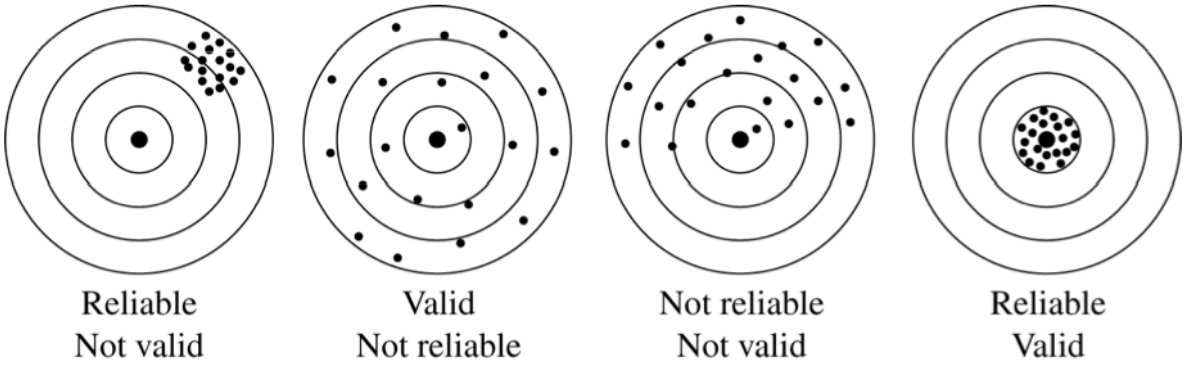


Figure 2: Relationship between reliability and validity

Reliability

In literature, some authors found good reliabilities for bipolar EMG probes for the pelvic floor. Thorp et al. performed a test-retest with 5 nulliparous premenopausal asymptomatic women (6). Thompson et al. used 8 premenopausal or using hormonal replacement therapy asymptomatic women with 0 to 3 parity for this(7). Glazer et al. performed a test-retest on 37 volunteers(8). This population was a mix of asymptomatic and symptomatic women with 0 to multiple parity, most of them with multiple dysfunctions. The mixed population makes the results difficult to interpret. It should be also noted that comparison across these studies is impossible as they have used different probes and subjects performed different tasks.

Auchlincloss et al. state that these significant limitations (mixed populations and the use of bipolar configurations) could have led to misinterpretations of the reliabilities. Also the placement and replacement is questionable according to them.

Auchlincloss et al. also performed a test-retest with 10 asymptomatic nulliparous women. They conclude that, although it is acceptable to use the Femiscan and Periform as a biofeedback tool for training purposes, it is not recommended for the use to make between subject comparisons or to use as an outcome measure between-days when evaluating PFM, because the test-retest reliability was poor(3).

The MAPLe uses a unipolar configuration. The test-retest reliability for the MAPLe,

done with 20 volunteers divided in 4 different groups (men, women nulliparous premenopausal and parous pre- and postmenopausal) performing 3 different tasks (rest, maximal voluntary contraction and endurance), was rated moderate to excellent. Literature furthermore shows that the MAPLe is capable of differentiating between individual muscles within the groups and to detect significant differences between the groups (5).

Validity

Almost all commercially available probes have large electrodes, which are in circumferential or longitudinal direction and have large detection surfaces. When positioning these probes in the vagina or anal canal, these electrodes cover multiple muscles on multiple sides or different depths or the electrodes are even placed above the muscles of interest(2)(3)(4). Also the placement and replacement could be an issue because there is no fixed location for the depth or orientation. The acquired EMG activity is therefore a composed signal from various muscles. Furthermore, the large electrode surface makes most probes sensitive for cross-talk. Besides this, they are used in a bipolar configuration. This results either in one differential signal between the left side and the right side of the pelvic floor (in case of two longitudinal electrodes) or one differential signal between the superficial and deeper parts of the pelvic floor (in case of two circumferential electrodes). This is not a valid measurement method and can be likened to placing an electrode on the left bicep and one on the right bicep during a task to record a differential EMG signal from the biceps muscle(3). Thus it is not valid to qualify the differential signal as EMG activity of the pelvic floor.

The MAPLe is the only commercially available probe which is used in a unipolar configuration(5). This makes the MAPLe valid for comparison between other muscles and between individuals. Furthermore, the location of the electrodes is validated in MRI and 2D and 3D ultrasound. The results show that the single electrodes are located nearest to the individual muscles of the pelvic floor(5). Also, the MAPLe has small electrode surfaces, making it less sensitive for cross-talk. Besides this, the size of the probe (15mm in circumference) is chosen to be as minimally invasive as possible

to prevent a reaction of the PFM to the presence of the probe. Also, the MAPLe has a standard location for orientation and depth, assuring an optimal placement and replacement of the probe.

In 250 asymptomatic volunteers, divided in 4 different groups (men, women nulliparous premenopausal and parous pre- and postmenopausal) performing 3 different tasks (rest, maximal voluntary contraction and endurance), the MAPLe could differentiate between individual muscles within groups and found significant differences between individual muscles between the groups within and between tasks(5). These outcomes are in line with other literature, stating that gender, parity, menopause and performed task influence the (EMG of the) PFM. Furthermore the anatomy and recent insights in innervation of the pelvic floor underline these findings(10).
In a recently published article, the MAPLe was used in the diagnosis and treatment of women suffering from the overactive bladder (OAB) syndrome. The study shows the effect of biofeedback assisted pelvic floor muscle therapy after nine weeks of treatment. In 50 symptomatic women it is shown that there are changes in individual PFM, measured with the MAPLe which are relevant and can be related to symptom reductions. The local changes in EMG of the individual muscles are confirming the restoration of the guarding reflex, which is an important mechanism for the suppression of urge(11).
The findings in these two studies support the validity of the MAPLe.

Conclusion

Commercially available bi-polar EMG probes are not valid to use as a comparison between different sessions within patients and comparison between patients. Besides this, the electrodes of these probes cover multiple muscles, making the resulting differential signal invalid and unfitted for any comparison.
On the contrary, the electrodes of MAPLe are located nearest to the individual muscles of the pelvic floor and capable of differentiating between these muscles. Research shows that it is proven to be reliable and valid. This makes it possible to make a comparison of EMG activity of individual muscles within and between patients.

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