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Review Article

Neuromuscular Response What is it and How to Measure it?

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ABSTRACT

The neuromuscular response or neuromuscular function is a set of biomechanical and viscoelastic properties about the muscular and fascia tissue. These characteristics are fundamental for the rehabilitation and sport medicine. This is a review of how to measure neuromuscular response and to define this concept, its parameters and present different tools (myometry and tensiomyography) to measure it.

INTRODUCTION

The Neuromuscular Response or Neuromuscular Function (NMR) is a set of biomechanical and viscoelastic properties about the myofascial tissue that prepare the muscle to perform a mechanical work as a result of muscular and nervous system function [1]. It determines the muscular performance during the movement task, its rehabilitations and its training. These parameters could be useful to assess muscle pathological or injury effects [2-4], as well as the therapeutic improvement in this tissue [5-7]. Many techniques have been used in order to measure the NMR since the mid-twentieth century, for example the Magnetic Resonance Imaging (MRI) or the Muscle Electromyography (EMG) activity. Even invasive methods have also been used in order to analyze the relationship between the contractile and histological muscle properties [8]. However, at the end of that century and the beginning of the 21st, new muscle assessment methods and tools began to be developed, such as Tensiomyography (TMG) and Myometry (MMT). Although MRI and EMG have been widely studied and lot of research has been done with these tools, few studies are available using TMG and MMT.

The aim of this review was to explain how to measure neuromuscular response and to define this concept, its parameters and newest different tools to measure it.

TENSOMYOGRAPHY

The Tensiomyography (TMG) is a tool to evaluate the muscle involuntary contractile properties and how its viscoelastic properties can influence its performance [9]. It measures parameters such as the muscle belly maximal radial displacement when it is activated by a controlled electrical stimulus [10-12]. TMG uses electrical stimulation applied percutaneously which causes a muscle contraction (Figure 1). This contraction is detected by a digital transducer applied to the muscle belly [11]. It has a good and high reliability that ranges between 0.5-2% and high reproducibility (ICC between

0.85-0.98) [13-16]. By the TMG, it can be measured the followings parameters (Figure 2 and Table 1)

Figure 1: TMG procedure.

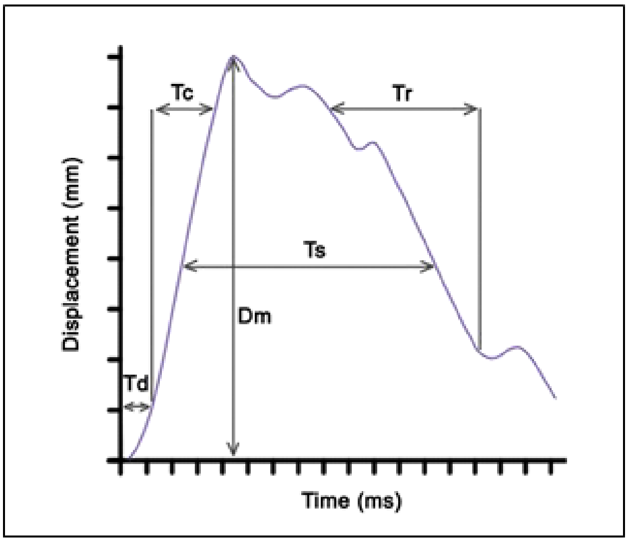

Figure 2: NMR response and TMG values.

Maximalradial Displacement (Dm)

It is the maximal radial displacement value expressed in mm. The Dm informs about muscle stiffness and it varies depending on muscle fibers disposition, volume and training. Although it is difficult to establish reference values for the Dm of the different muscles [17-19], this value tells us about the muscle tone. High values of Dm show lack of tone or fatigue; while low values show high muscle tone or stiffness [15,20,21].

Delay Time (Td)

It is measured in ms. It is the time that takes the muscle to reach from the start of the stimulus to the 10% of the total displacement of the contraction [17,19].

Contraction time (Tc)

It is measured in ms. It is the time between the 10% and 90% of the muscle displacement. Its values vary according to the muscle fiber type and fatigue [22]. Low Tc values are found in muscles with type II (white) or fast-twitch fibers predominance and high values are found in muscles with type I (red) or slow-twitch fibers predominance. The average values are usually around 28-29 ms [18] although there are authors who consider values above 30 ms as a cutoff value. The Tc is useful to distinguish athlete's types regarding their muscular qualities and to assess the workloads influence, the activation level or the fatigue during a training 139.

Sustained time (Ts): It represents the contraction sustaining time and it is measured in ms. It is the time from the 50% of the displacement reached in the contraction phase to the 50% of the displacement in the relaxation phase [17,19].

Combining all of these parameters, it is possible to obtain the **contraction velocity (Vc),** which represents the muscle radial deformity over time. It is really useful to determine the muscle fiber type predominance. Vc values will be low in endurance athletes with a high percentage of type I fibers and, on the other side, it will be high in athletes with explosive activity and a high percentage of type II or fast-twitch fibers [3,12].

MYOMETRY

The Myometry (MMT) is a non-invasive tool which assesses the viscoelastic muscle, fascia and connective tissue properties (either in the tension or rest state), [23]. It has a good reliability observed by different studies among healthy and injured population [24-29] and has shown an excellent test-rest reliability (ICC = 0.80-0.93) [30,31]. The MMT is placed perpendicular to the structure and the device automatically performs a series of impulses (Figure 3). The tissue responds to the mechanical stimulus by damped oscillations that are recorded by an acceleration sensor and processed by an internal microprocessor. Following parameters are obtained using this oscillations average value (Figure 4 and Table 1).

Figure 3: MMT procedure.

Muscle tone (Hz)

It is defined as the muscle intrinsic tension at cellular level in a rest state. In cases of high muscle tone, correct blood supply is restricted, which causes earlier muscle fatigue and it could delay the recovery [32].

Stiffness (N/m)

It is the biomechanical muscle property that characterizes the resistance to an external force that deforms its initial shape [33].

Elasticity

It is the biomechanical muscle property that characterizes the ability to recover its initial shape after the elimination of an external force that deforms it. The elasticity is calculated from the record of the amplitude decrease [32], and it represents the mechanical released energy during an oscillation cycle.

Relaxation (m/s)

Is the time for a muscle to recover its shape from after the removal of an external force (ms) [33].

Creep

It is the tissue gradual elongation over time when placed under a constant tensile stress [32,33].

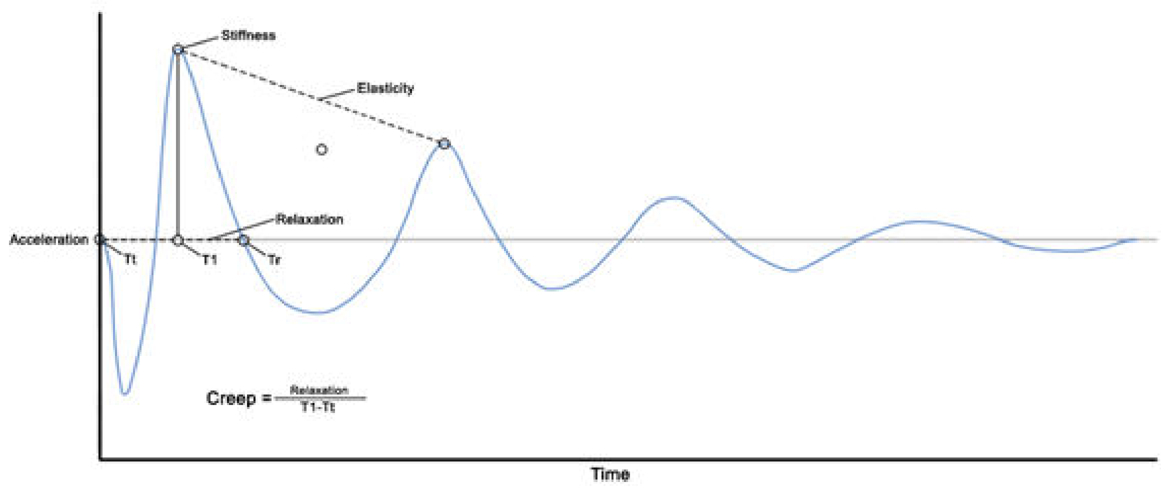

Figure 4: NMR response and MMT values.

Table 1: measures reliability

Outcome	Measuring instrument	Provided information	Reliability
Maximal Radial displacement (Dm)	Tensiomyography	Maximal radial displacement of the muscle contraction or its stiffness	0.97 a 0.86 0.98 [34] 0.98 [15] 0.98 [35] 0.97 [16] 0.86 [36] 0.92 [37] 0.95 [38,39]
Delay time (Td)	Tensiomyography	Time between an electrical impulse and 10% of the contraction	0.91 [34] 0.94 [15] 0.94 [35] 0.86 [16] 0.60 [36] 0.89 [37] 0.82 [38,39]
Contraction time (Tc)	Tensiomyography	Time between 10% and 90% of the contraction after an impulse	0.92 [34] 0.97 [15] 0.98 [35] 0.92 [16] 0.62 [36] 0.83 [37] 0.86 [38,39]
Sustained time (Ts)	Tensiomyography	Time between 50% of the contraction and 50% of the relaxation after an impulse	0.81 [34] 0.89 [15] 0.94 [35] 0.96 [16] 0.78 [36] 0.90 [37] 0.94 [38,39]
Relaxation time (Tr)	Tensiomyography	Time between 90% and 50% of the relaxation. It indicates muscular fatigue	0.42 [34] 0.86 [15] 0.88 [35] 0.77 [16] 0.79 [36] 0.88 [37] 0.78 [38,39]
Tone	Myometry	Intrinsic tension on the cellular level	0,91-0,96 [40,41]
Stiffness	Myometry	Resistance to a contraction or to an external force that deforms its initial shape	0,91-0,96 [40,41]
Elasticity	Myometry	Ability to recover the muscle initial shape after a contraction or removal of an external force of deformation	0,78-0,86 [40,41]
Relaxation time	Myometry	Time to recover the muscle initial shape after a contraction or removal of an external force of deformation	
Creep	Myometry	Ratio of deformation and relaxation time. Gradual elongation of a tissue over time when placed under a constant tensile stress.	

METHODOLOGICAL CONSIDERATIONS FOR THE NEUROMUSCULAR RESPONSE STUDY

Regarding the recommendations made by Rodríguez-Matoso et al., [42]. In order to do a correct NMR measurement, it is necessary to follow the next considerations:

1. To analyze only the musculature or subcutaneous fascial tissue. In people with large amounts of adipose tissue or deep muscles, measurement will not be feasible.

2. To state correctly the segments to be studied. Changes in the position will alter the measurement. So it is important to measure it always with the same subject position.

3. Accurate sensor placement. Although with the myometry the sensor placement could be different (depending on whether we want to analyze the fascia muscle), in the tensiomyography the sensor placement must be in the most prominent area of the muscle and in the middle of the electrodes that will cause the electrical contraction.

4. To avoid muscle tissue tetanization. In the case of using the TMG it is advisable to space the contraction discharges in order to avoid muscle tissue tetanization. If you want to use both tools, it is better to use firstly the myometry in order to avoid tone changes.

5. To avoid studying fatigued muscle, unless you want to analyze this muscle condition.

6. To check the ambient and segment temperature before the measurement. The NMR is a set of biomechanical and viscoelastic muscle properties so the temperatures changes could alter them.

CONCLUSION

The neuromuscular response is a set of parameters that allow us to assess the myofascial tissue state (fascia and muscle). These parameters can help both the physiotherapist and the physical trainer to know about this tissue state. It is important in order to prevent injuries and to plan training or treatments. Myometry (or myoton) and tensiomyography are two non-invasive tools that allow us to know about muscle properties with a good reliability. The principal strength of these two tools is that they are both cheaper than MRI and EMG activity. Moreover, they are easily transportable and small enough to facilitate his use. On the other hand, one important limitation of these two tools is that they did not take into account the subject willfulness. Future studies are necessary to know different treatments or training effects in the NMR.

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