INFRASPINATUS ELECTROMECHANICAL DELAY ON SHOULDER INSTABILITIES

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SUMMARY

Shoulder instability is a major complaint in overhead athletes. The shoulder joint stability is provided mainly by rotator cuff muscles. The Electromechanical Delay (EMD) may be an important parameter in the responsiveness of a muscle. The aim of this study was to measure and compare the infraspinatus EMD in healthy and unstable shoulders and in dominant and non-dominant shoulders. We did not find any difference between the groups. Our results do not support the hypothesis that the infraspinatus EMD is increased in shoulder instability.

INTRODUCTION

Shoulder instabilities caused by sports practice are a common complaint, especially among overhead athletes. The maintenance of glenohumeral stability is mainly provided by rotator cuff muscles that act to center the humeral head on glenoid fossa. In sports practice, the angular velocity can reach more than 6500°/s [1], demanding a prompt response of the shoulder stabilizer muscles. The ability of the rotator cuff muscles to respond quickly to maintain shoulder stability depends on many factors. One of these factors is the Electromechanical Delay (EMD which is basically the time gap between the electrical activation and the torque production. A high EMD could postpone the joint stabilization, resulting in the loss of correct joint alignment, and possibility leading to injuries or chronic stress to ligaments, that could possibly lead to more instability.

Some studies have revealed the increase in EMD in patients with ankle instability during a sudden inversion while standing [2,3]. The rotator cuff is the most important muscle group in stabilization of the humeral head, of these, infraspinatus muscle provides the most reliable measurement because it's directly under the skin. During a quick external rotation (ER) the infraspinatus is initially electrically activated (measured by EMG), then it begins to vibrate as a result of mechanical activation (measured by mechanomyography (MMG) and finally the torque is generated at the joint. The time gap between these three events can demonstrate some mechanical properties of the muscles. A delay in any of those intervals could predispose the overhead shoulder to move to a position where the humeral head is not in the proper position to perform the movement with healthy biomechanics.

Esposito, Limonta and Cè [4] found an increase in the time between EMG and MMG after a stretching protocol of triceps surae muscles. A similar change in the rotator cuff muscles could alter the stabilization times leading to instability or injury.

Therefore, the objective of this study was to observe EMD of the infraspinatus muscle (in its 3 components) during external rotation in healthy and unstable shoulders. Our hypothesis is that the unstable shoulder would have a higher EMD.

METHODS

A sample of 12 male recreational volleyball players without previous injuries in the upper limbs, aged between 17 and 35 years were recruited. The subjects had both shoulders tested (total of 24 shoulders), and instability was diagnosed by specific orthopaedic tests. From 12 subjects, 5 were placed in the unstable group and 7 in the stable group. Surface electromyography signal (EMG) and mechanomyography signal (MMG) from infraspinatus and external rotation shoulder torques (T) were all collected at 2 kHz for both shoulders (stable and unstable). The EMG and MMG placement were done 4 cm caudally to spine of scapula, parallel to muscle fibers [5]. EMG signal was filtered with a 6^{th} order Butterworth with a bandpass of 20-450 Hz, rectified and a linear envelope was calculated. The MMG signal was filtered using a 3^{rd} order Butterworth bandpass of 4-40 Hz.

The activity onsets of EMG and MMG were found using the mean ± 3sd from the filtered resting signal. The torque onset was defined as the first point that reached 2% of maximal torque. using the three onsets, the EMD (Δt EMG-T), Δt MMG-T and Δt EMG-MMG, were calculated for both groups.

The statistical analysis was performed by verifying the normal distribution using the Kolmogorov-Smirnov test. After that a two-way ANOVA comparison between groups (dominant Vs. non-dominant in healthy shoulders and Stable Vs. Unstable shoulders) was done to all three time lags (Δt EMG-T, Δt MMG-T and Δt EMG-MMG). The statistical significance adopted was α=0.05.

RESULTS AND DISCUSSION

Figure 1 summarizes the results in the delay between onsets in stable and unstable shoulders. The blue bars represent the stable shoulders and the red bars represent the unstable shoulders.

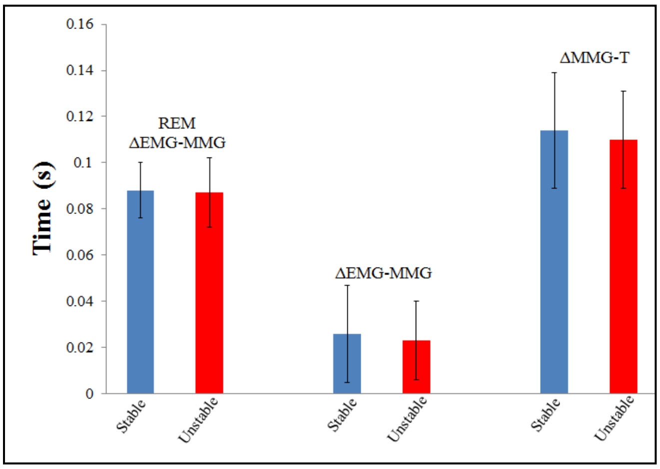

Figure 1. Time between events. Blue bars represent stable shoulders, red bars represent unstable shoulders.

No statistical differences were found in any of the parameters between stable and unstable shoulders or between dominant and non-dominant shoulders (p>0.05).
We expected that the EMG would be the first signal to achieve the onset threshold, but in most signals the MMG onset happened earlier. Therefore, the Δt EMG-MMG delay shown in Figure 2 is actually the MMG preceding the EMG.
During a muscle contraction, the first event to happen is the muscle electrical activation (measured by EMG), then the muscle starts to move and contract (vibration measured by the MMG) and then the force is transmitted to bones resulting in articular torque generation (measured by the dynamometer).
An example of the signal is showed in Figure 2. The blue line represents the EMG envelope, the green line the filtered MMG and the red line the torque.
It can be can observed that the MMG onset was the first (dark gray shaded area represents Δt EMG-MMG), followed by the EMG onset and after that the torque (light gray shaded area represent the EMD).

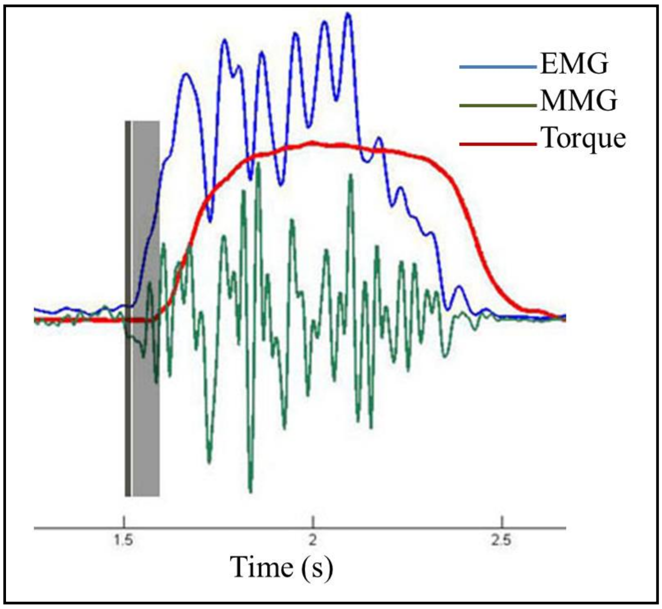

Figure 2: Example of data signal onset. the dark gray bar represents Δt EMG-MMG and the light gray bar the EMD.

Although unexpected, this behavior may represent the activation of other muscles prior to infraspinatus. Some other stabilizing muscles, for example the remaining rotator cuff muscles or scapular muscles, could have been activated before infraspinatus.
In contrast to the findings in ankle joint instability and increased EMD, we could not find any change in infraspinatus EMD when comparing the stable and unstable shoulders or dominant with non-dominant shoulders. We had hypothesized that a shoulder with instability could show some delay in transferring the force from muscles to the joint and in this way, generate a higher EMD.
During voluntary contractions the motor units are activated asynchronously leading to a slower increase in EMG [5] while in electrically stimulated muscles the activation is more synchronic. The studies we reviewed that found EMD changes used reflexive contractions [2,3] or electrical stimulation [4], this being probably related to the rate increase in EMG signal and rate of force development. Another of the limitations of the study is that we did not measure the EMD in muscles other than infraspinatus. The EMD of the remaining rotator cuff muscles may be associated with shoulder instability.

CONCLUSIONS

MMG evaluation may not be a good parameter to measure muscle vibration in infraspinatus muscle. The infraspinatus EMD do not appears to be related to the pathogenesis of the shoulder instability.

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REFERENCES

1. Escamilla RF, Andrews JR. Shoulder muscle recruitment patterns and related biomechanics during upper extremity sports. *Sports Med*, **39**:569-590, 2009.
2. Mora I, Quinteiro-Blondin S, Perot C, Electromechanical assessment of ankle stability. *Eur J Appl Physiol*. **88**: 558–564, 2003.
3. Hopkins TJ, Brown TN, Christensen L, Palmieri-Smith RM. Deficits in Peroneal Latency and Electromechanical Delay in Patients with Functional Ankle Instability. *J Orthop Res.* **27**:1541–1546, 2009.
4. Esposito F, Limonta E, Cè E. Passive stretching effects on electromechanical delay and time course of recovery in human skeletal muscle: new insights from electromyographic and mechanomyographic combined approach. *Eur J Appl Phys*. **111**:485-495, 2011.
5. Eleanor Criswell. *Cram's Introduction to Surface Electromyography*. p.302, 2ed, 1998.
6. Linnamo V, Moritani T, Nicol C, Komi PV. Motor unit activation patterns during isometric, concentric and eccentric actions at different force levels. *J Electromyo Kin*. **13**:93-101, 2003.