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Original article

The neuromotor effects of transverse friction massage

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ABSTRACT

Background: Transverse friction massage (TFM), as an often used technique by therapists, is known for its effect in reducing the pain and loosing the scar tissues. Nevertheless, its effects on neuromotor driving mechanism including the electromechanical delay (EMD), force transmission and excitation-contraction (EC) coupling which could be used as markers of stiffness changes, has not been computed using ultrafast ultrasound (US) when combined with external sensors.
Aim: Hence, the aim of this study was to find out produced neuromotor changes associated to stiffness when TFM was applied over Quadriceps femoris (QF) tendon in healthy subjcets.
Methods: Fourteen healthy males and fifteen age-gender matched controls were recruited. Surface EMG (sEMG), ultrafast US and Force sensors were synchronized and signals were analyzed to depict the time delays corresponding to EC coupling, force transmission, EMD, torque and rate of force development (RFD).
Results: TFM has been found to increase the time corresponding to EC coupling and EMD, whilst, reducing the time belonging to force transmission during the voluntary muscle contractions.
Conclusions: A detection of the increased time of EC coupling from muscle itself would suggest that TFM applied over the tendon shows an influence on changing the neuro-motor driving mechanism possibly via afferent pathways and therefore decreasing the active muscle stiffness. On the other hand, detection of decreased time belonging to force transmission during voluntary contraction would suggest that TFM increases the stiffness of tendon, caused by faster force transmission along non-contractile elements. Torque and RFD have not been influenced by TFM.

1. Introduction

Transverse friction massage, described by James Cyriax in the 1940 (Kesson and Atkins, 1998), has often been used in chronic inflammatory conditions such as lateral epicondylitis, iliotbial band friction syndrome or patellar tendinitis. TFM promotes local hyperemia, analgesia and the reduction of adherent scar tissue to ligaments, tendons, and muscles (Yoo et al., 2012). It makes scar tissue more mobile in sub-acute and chronic inflammatory conditions by realigning the normal soft tissue fibers (Brosseau et al., 2002). Therefore, it is expected that TFM reduces the stiffness (extensibility increases) of the soft tissue. Given its often clinical effectiveness, TFM has not been scrutinized enough in order to find out its effect on the neuromotor excitability or neuromotor driving mechanism which has a neural control over stiffness changes (Bennett et al., 2014).

It was shown that TFM reduces the excitability of the motoneuron pool when tested via H-Reflex, carried out as an electromyographic (EMG) response to a mild electrical shock to the nerve (Lee et al., 2009). The petrissage massage, performed as a rhythmic grasping and releasing of the muscle tissue reduces motor-neuron excitability as well via muscle spindles and golgi tendon organs, likely to be a centrally mediated inhibition from higher motor centers (Sullivan et al., 1991). Basically, a number of studies have agreed on this reduction of neuromotor excitability (Lee et al., 2009; Roberts, 2011; Goldberg et al., 1992; Newham and Lederman, 1997; Kassolik et al., 2009) and muscle stiffness when massage was applied over the muscle (Eriksson Crommert et al., 2015). Albeit a limited number of studies investigated the effect of massage

Abbreviations: EC, excitation-contraction; EMD, electromechanical delay; EMG, electromyography; MTJ, myotendinous junction; QF, quadriceps femoris; RF, rectus Femoris; RFD, rate of force development; RMS, root mean square; ROI, region of interest; SD, standard deviations; TFM, transverse friction massage; US, ultrasound.

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application over the tendon, a decrease in H-Reflex was observed, showing a reduction of neuromotor excitability in normal (Kukulka et al., 1986) and hemiparetic patients (Leone & Kukulka, 1988), after applied pressure on the Achilles tendon. This likely to be a centrally mediated inhibition has also been suggested to be a possible cause for the observed force reduction after a series of massage applications to the iliotibial band (Hunter et al., 2006). A decline in the power reduction was also reported after the massage of the gastrocnemius muscle (Shin & Sung, 2015). On the other hand, a comprehensive study has shown that massage reduces neuromotor excitability without affecting twitch contractile properties when interpreted by analyzing the peak torque and derived parameters (Behm et al., 2013). Therefore, to get some information about the changes of the contractile properties of the muscle after massage, the combined approach of using surface sensors became a plausible method depicting EC coupling of active contractile properties of muscle and force transmission of parallel elastic components of muscle, both contributors to the overall EMD (Esposito et al., 2011; Esposito et al., 2009). In the mentioned approach, combined sensors such as EMG, MMG and Strain gauge were timely synchronized where EMG provides important information of motor unit neural activation during muscle contraction, MMG provides information about dimensional changes of the transverse diameter of the muscle fibers and Strain gauge provides information about force output during a muscle contraction. The time lag between the onset of EMG and MMG signal generation during contraction was attributed to EC coupling while the time lag between MMG and Strain gauge signal generation was attributed to force transmission along parallel elastic components. In this approach, an MMG sensor was used as an external sensor placed over the muscle belly and a signal displayed was the summation of the surface oscillations including muscle, sub-cutaneous tissue and the skin itself. Very recently this method has been renewed where instead of an MMG sensor; an ultrafast ultrasound was used depicting muscle oscillations from a certain depth of the muscle tissue itself, therefore, excluding tissues above the muscle and possible artifacts produced thereby (Begovic et al., 2014). In this method, combined and timely synchronized EMG, Ultrafast ultrasound and Strain gauge prompted an investigation which would unveil potential changes of the contractile properties and force transmission after TFM applied over the quadriceps femoris tendon. These changes are displayed in terms of time delays between generations of each signal where time delay between EMG and US (muscle disturbance depicted from inside) onset provides an indication of EC coupling duration, while a time between US and Strain Gauge signal onset provides information about force transmission and stiffness of series elastic components. Hence the aim of our study was to find out what effects are produced in the muscle-tendon complex as a result of TFM applied over mechanoreceptor-rich tendon and myotendinous junction (MTJ). The time delays, belonging to EC coupling and force transmission, both contributing to EMD were computed during voluntary muscle contractions before and after TFM. It was hypothesized that TFM may produce twitch contractile changes (EC coupling) inside the muscle when detected by centrally mediated voluntary muscle contraction.

2. Methods

2.1. Subjects

Fifteen healthy male subjects and fifteen age-gender matched control subjects were recruited for the randomized control trial. Upon enrollment, participants were randomly assigned to TFM and control group using simple computer program to generate randomness. One of the subjects from TFM group was not compliant with experimental procedure; therefore, the subject was excluded from the study and final number of subjects included in TFM group was fourteen. All subjects were recruited from the Division of Interdisciplinary Biomedical Engineering with a very identical age. They were without any history of previous injury, metabolic or neurologic disease. Not one of them was involved in any vigorous exercise on a daily basis. Not one of subjects was familiar with particular group assignment or experimental procedure until the familiarization session. The human subject ethical approval was obtained from The Hong Kong Polytechnic UniversityHSEARS20140215001.

2.2. Experimental design

Before visiting the laboratory of the Interdisciplinary Biomedical Engineering Division at the Hong Kong Polytechnic University for experimental procedure, subjects participated in a familiarization session. The tested dominant leg including TFM was chosen as the leg with which the subject preferred to kick a ball. After the anthropometric measurements, subject was seated on the calibrated dynamometer (Humac/Norm Testing and Rehabilitation System, Computer Sports Medicine, Inc., MA,USA). The 30° of knee flexion was chosen to activate the muscle with minimum pre-stretching of the muscle fibers (Sasaki et al., 2011).

The experimental procedure was well standardised with a minimised risk of experimental bias as data acquisition and analysis were performed independent of each other at different times. The experimental procedure and signal analysis were performed mainly by authors, while TFM was performed by only one physical therapist.

Muscle activity during voluntary isometric contractions was recorded simultaneously by sEMG, Strain gauge and ultrafast US, while the subject was seated on the calibrated dynamometer with the knee flexion angle adjusted at 30° (Begovic et al., 2014) (Fig 1A). The test procedure consisted of 4 repeated isometric contractions followed by massage in TFM group and resting in control group and ended up again with 4 repeated contractions of the QF muscle. Between each contraction, a resting period of 2 min was allowed to prevent muscle fatigue (Shi et al., 2007). During the test, the subject was asked to apply maximum isometric contraction as quickly as possible in 1 s and to keep it approximately for 3 s. Verbal order was given to the subject about the start and termination of the muscle contraction. The order “start” was given immediately after starting the collection of A-mode signals in the ultrafast US device. After the termination of each contraction, the position of the US probe was checked to ensure that there was no displacement of the probe caused by the movement artifact of the muscle during contraction (Begovic et al., 2014; Shi et al., 2008; Shi et al., 2007; Strasser et al., 2013; Guo et al., 2010; Wang et al., 2014).

2.3. Electromyography

Two surface EMG bipolar Ag–AgCl electrodes (Axon System, Inc., NY, USA) for differential EMG detection were attached on the RF muscle belly, approximately at the 50–60% of the distance between the spina iliaca anterior superior and superior patellar margin. To reduce the skin impedance, skin was cleaned with isopropyl alcohol and abraded with fine sandpaper. The ground electrode was placed over the tibial crest. Interelectrode distance between two sEMG electrodes was 30 mm. The sEMG signal was amplified by a custom designed amplifier with a gain of 2000, filtered by 10–1000 Hz bandpass analog filter within the amplifier, and digitized with a sampling rate of 4 KHz (Begovic et al., 2014; Guo et al., 2010).