Journal of Electromyography and Kinesiology 23 (2013) 1215–1221

Contents lists available at SciVerse ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

Massage and stretching reduce spinal reflex excitability without affecting twitch contractile properties

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ARTICLE INFO

Article history:
Received 19 March 2013
Received in revised form 24 April 2013
Accepted 9 May 2013

Keywords:
H-reflex
M-wave
Muscle
Tapotement
Electromechanical delay

ABSTRACT

Both stretching and massage can increase range of motion. Whereas the stretching-induced increases in ROM have been attributed to changes in neural and muscle responses, there is no literature investigating the ROM mechanisms underlying the interaction of stretch and massage. The objective of this paper was to evaluate changes in neural and evoked muscle responses with two types of massage and static stretching. With this repeated measures design, 30 s of plantar flexors musculotendinous junction (MTJ) and tapotement (TAP) massage were implemented either with or without 1 min of concurrent stretching as well as a control condition. Measures included the soleus maximum H-reflex/M-wave (H/M) ratio, as well as electromechanical delay (EMD), and evoked contractile properties of the triceps surae. With the exception of EMD, massage and stretch did not significantly alter triceps surae evoked contractile properties. Massage with and without stretching decreased the soleus H/M ratio. Both TAP conditions provided greater H/M ratio depression than MTJ massage while the addition of stretch provided the greatest inhibition. Both massage types when combined with stretching increased the duration of the EMD. In conclusion, MTJ and TAP massage as well as stretching decreased spinal reflex excitability, with TAP providing the strongest suppression. While static stretching prolongs EMD, massage did not affect contractile properties.

1. Introduction

Both stretching and massage techniques have been used in an attempt to acutely increase joint range of motion (ROM). The effectiveness of static stretching (SS) to acutely increase ROM (Behm et al., 2001, 2004, 2006, 2011) has been attributed to both neural and muscular factors (Behm and Chaouachi, 2011). SS-induced muscle changes include increases in musculotendinous unit (MTU) length and stiffness (Alter, 1996; Wilson et al., 1991) as well as an increased tolerance to stretch (Magnusson et al., 1996). Evidence has also been presented to show a SS-induced reduction of the H-reflex amplitude, representing decreased spinal reflex excitability (Avela et al., 1999; Guissard et al., 1988, 2001).

The effectiveness of massage to increase ankle dorsiflexion ROM is more controversial. Three minutes of petrissage (kneading actions) and tapotement (percussive strokes) similarly increased ankle joint ROM by 3–4% (McKechnie et al., 2007). Thirty seconds of musculotendinous junction (MTJ) massage improved hip flexor ROM by approximately 7% (Huang et al., 2010). Dynamic soft tissue mobilization has been reported to provide greater or equal increases in hamstring flexibility compared to classic soft tissue mobilization or massage (Hopper et al., 2005a,b). Conversely, 15 min of effleurage (circular stroking movements) and petrissage did not increase sit and reach scores with healthy active males (Barlow et al., 2004) or adolescent soccer players (Jourkesh, 2007). Fifteen minutes of petrissage did not improve ROM of hip abduction, extension, flexion and knee extension but augmented ankle dorsiflexion ROM in healthy men. Stretching in that same study was found to be more effective than massage to increase ROM (Wiktorsson-Moller et al., 1983).

Not all massage techniques are intended for the same purpose. Whereas techniques such as effleurage aim to promote relaxation (Weerapong et al., 2005), the objective of tapotement is to stimulate sensory (mechanoreceptors) receptors (Morelli and Sullivan, 1999; Weerapong et al., 2005). Light (Goldberg et al., 1992) and deep (Goldberg et al., 1992) petrissage massage of the triceps surae with one hand (Morelli et al., 1990; Sullivan et al., 1991) have all resulted in H-reflex amplitude depression with deep petrissage providing greater inhibition than light massage. A massage

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http://dx.doi.org/10.1016/j.jelekin.2013.05.002

intervention that included effleurage, petrissage and tapotement negatively affected isokinetic muscle strength at high speeds, which was attributed to possible increases in parasympathetic input and decreased afferent feedback resulting in decreased motor unit activation (Arroyo-Morales et al., 2011).

As massage techniques are transmitted to the muscle through the skin, the activity of the cutaneous afferents would be expected to play a role in the excitation or inhibition of the central nervous system. Sayenko et al. (2009) used non-noxious electrical plantar cutaneous afferent stimulation of the heel and metatarsal regions and reported both soleus H-reflex facilitation and inhibition with short and long durations respectively when applied to the heel. However, both stimulation durations resulted in H-reflex depression when applied to the metatarsals. Stimulation of flexor carpi radialis cutaneous afferents with single 10 ms duration pulses from a probe attached to an electromagnetic vibrator produced an immediate H-reflex decline (2 ms) followed by a facilitation lasting 10 ms (Cavallari and Lalli, 1998). Hence, the H-reflex response can be quite variable dependent upon the type, duration and location of the stimulation.

As there is no information on the effect of massage on muscle contractile properties, it is unknown whether massage-induced increases in ROM (Huang et al., 2010; McKechnie et al., 2007) can be attributed more to mechanical or neural factors. An examination of electromechanical delay (EMD) would provide insights regarding changes to musculotendinous compliance. Monitoring twitch contractile properties would help gauge massage-induced muscle changes in force and temporal properties. Thus one objective of this research was to investigate possible changes in maximal H-reflex/M-wave (H/M) ratios as a surrogate of spinal reflex excitability (Trimble and Enoka, 1991) with combinations of SS, tapotement and MTJ massage. As the H/M ratio represents a valid indicator of spinal-mediated neural changes to massage and SS, another objective was to examine changes in twitch contractile properties with massage and SS to highlight neural versus muscular alterations. It was hypothesized that the MTJ massage technique and SS would reduce the H/M ratio whereas tapotement would increase the H/M ratio with no significant effect on muscle contractile properties.

2. Materials and methods

Based on previously published related articles (Avela et al., 1999; Etnyre and Abraham, 2005; Goldberg et al., 1992; Guissard et al., 1988, 2001) a statistical power analysis was conducted to ensure an alpha of 0.05 and a power of 0.8. Seventeen recreationally active university student participants (13 females: 169.6 ± 6.4 cm, 70.3 ± 8.9 kg, 22.2 ± 0.8 years and 4 males: 180.2 ± 2.1 cm, 90.5 ± 11.7 kg, 31 ± 8.4 years) from Memorial University of Newfoundland volunteered for the study. All subjects were healthy with no history of neurological impairments. A verbal overview of procedure and purpose of the study was given to all subjects. A signed Physical Activity Readiness Questionnaire (Canadian Society for Exercise, 2003) was collected from all subjects before participation. All subjects signed written informed consent form before their participation in the study. Subjects were instructed to not smoke, drink alcohol, or exercise at least 6 h prior to testing and to not eat food or caffeinated beverages for at least 2 h prior to testing (Canadian Society for Exercise, 2003). The Human Investigation Committee of the Memorial University of Newfoundland approved this study.

2.1. Experimental protocol (Fig. 1)

Participants were seated with the ankle fixed in an isometric boot apparatus (Fig. 2) equipped with strain gauges (Omega Engineering Inc. LCCA 250, Don Mills Ontario, Canada) (Behm et al., 2002) and were randomly subjected to the following conditions on five separate testing days: (1) MTJ massage, (2) tapotement massage, (3) MTJ massage with stretch, (4) tapotement massage with stretch and (5) control (no massage or stretch). Following a pre-intervention test, a massage intervention was instituted for 30 s (MTJ, MTJ with stretch, tapotement or tapotement with stretch), followed by another 30 s of no massage but continued stretch position for two of the conditions (MTJ and tapotement massage with stretch). Thirty seconds of massage was chosen based on the Huang et al. (2010) article, which demonstrated significant (7%) increases in ROM following 30 s of MTJ massage. After 60 s, the ankle joint was returned to a neutral position (for the two massage with stretch conditions). Testing was conducted pre-test, 15, 30, 45 and 60 s into the intervention period and at 1 and 2 min post-intervention. Dependent variables included soleus H/M ratio, plantar flexors twitch contractile properties (peak torque, time to peak torque, half-relaxation time (HRT)), soleus M-wave amplitude and electromechanical delay (EMD).

2.2. Interventions (independent variables)

A certified massage therapist provided the massage. While seated with knees and hips at 90°, and the right leg inserted into the isometric boot apparatus, subjects received either MTJ or tapotement massage for 30 s. Two experimental conditions involved only massage with the ankle at 90° (MTJ and tapotement conditions) whereas the two other conditions involved MTJ or tapotement massage with the ankle placed in a maximal dorsiflexed position for 60 s (first 30 s with massage and second 30 s without massage). The ankle was in a neutral (90°) position (without massage) for the control condition. During the control condition the massage therapist placed his hands on the triceps surae without movement or substantial pressure.

Pre-test	15s	30s	45s	60s	Post-intervention 1 min (120s after pre-test)	Post-intervention 2 min (180s after pre-test)
Conditions	TAP + MTJ No Static Stretch 90^0 Angle		No Static Stretch 90^0 Angle		Neutral Position 90^0 Angle	
Conditions	TAP + MTJ With Static Stretch		Static Stretch			
	Control					
Test Measures	H-reflex / M-wave ratio, H-reflex latency, EMD, twitch force, twitch rate of force development, ½ relaxation time, M-wave amplitude					

Fig. 1. Experimental Protocol. Acronyms: TAP: tapotement massage of gastrocnemius, MTJ: musculotendinous junction massage of Achilles tendon and soleus muscle, EMD: electromechanical delay.