Sensorimotor Control During Peripheral Muscle Vibration: An Experimental Study

Jean-Alexandre Boucher, DC,[a] Martin C. Normand, DC, PhD,[b]
Éric Boisseau, DC,[c] and Martin Descarreaux, DC, PhD[d]

Abstract

Objective: The aims of this study were to determine whether the application of vibration on a postural lower limb muscle altered the sensorimotor control of its joint as measured by isometric force production parameters and to compare present findings with previous work conducted on trunk muscle.

Methods: Twenty healthy adults were asked to reproduce submaximal isometric plantar flexion under 3 different conditions: no vibration and vibration frequencies of 30 and 80 Hz on the soleus muscle. Time to peak torque, variable error, as well as constant error and absolute error in peak torque were calculated and compared across conditions.

Results: Under vibration, participants were significantly less accurate in the force reproduction task, as they mainly undershot the target torque. Applying an 80-Hz vibration resulted in a significantly higher negative constant error than lower-frequency vibration (30 Hz) or no-vibration condition. Decreases in isometric force production accuracy under vibration influence were also observed in a previous study conducted on trunk muscle. However, no difference in constant error was found between 30- and 80-Hz vibration conditions.

Conclusion: The results suggest that acute soleus muscle vibration interferes with plantar flexion torque generation by distorting proprioceptive information, leading to decreases in accuracy of a force reproduction task. Similar results in an isometric trunk extension force reproduction task were found with vibration applied on erector spinae muscle. However, high-frequency vibration applied on soleus muscle elicited higher force reproduction errors than low-frequency stimulation. (J Manipulative Physiol Ther 2015;38:35-43)

Key Indexing Terms: *Vibration; Torque; Muscle Spindles; Proprioception; Soleus Muscle*

Vibration exercise has been shown to improve muscle activity, force, and power via neurogenic potentiation.[1–5] When applied on a muscle belly or tendon, mechanical vibration also becomes a valuable tool for studying the relative contribution of muscle spindles in proprioception and motor control.[6] It is well known that the primary spindle endings, via the large Ia afferent fibers, feed the central nervous system with inputs about changes in the length of load-bearing muscles for both sensorimotor and perceptual purposes.[7–12] In the central nervous system, vibration stimulation is interpreted as a stretching of a muscle resulting in an integration of proprioceptive inputs that does not reflect the actual body position or state of muscle elongation.[13–15] This erroneous interpretation induces, in some circumstances, illusions of movements,[16–18] motor effects such as contraction of the muscle being vibrated (the tonic vibratory reflex),[19–21] or compensatory postural responses.[22–24] Mechanical vibration of sufficient amplitude and frequency can result in a selective activation of the Ia afferent, whereas the II and Ib afferents are either insensitive or only slightly sensitive to such stimulation.[13,15,25] Globally, neurophysiological studies show that motoneuron response is locked to the frequency of the vibratory stimulus in relaxed human muscles[13,26]; but this phase-lock decreases in the presence of a voluntary isometric contraction.[25] Numerous human studies have shown the motor unit firing rate to be altered with vibration, but the effects are dependent on the experimental protocol and the instructions provided to the participants.[27] For example, Griffin et al[28] showed that intermittent vibration

[a] PhD student, Département de psychologie, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada.
[b] Professor, Département de chiropratique, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada.
[c] Master Student, Département de kinésiologie, Université de Montréal, Montréal, Québec, Canada.
[d] Professor, Département des sciences de l'activité physique, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada.
Submit requests for reprints to: Jean-Alexandre Boucher, DC, Département de chiropratique, Université du Québec à Trois-Rivières, 3351, Boul des Forges, CP 500, Trois-Rivières, Québec, Canada, G9A 5H7. (e-mail: *charljea@uqtr.ca*).
Paper submitted December 10, 2013; in revised form August 1, 2014; accepted August 28, 2014.
0161-4754
Copyright © 2015 by National University of Health Sciences.
http://dx.doi.org/10.1016/j.jmpt.2014.10.013

applied to the triceps brachii tendon during a fatiguing isometric contraction reversed the previously decreasing motor unit discharge rate. Grande and Cafarelli,[29] however, demonstrated that intermittent vibration led to brief decreases in motor unit firing rate during a nonfatiguing contraction of the knee extensors. As a whole, vibration is likely to increase motoneuron excitation and the firing rate of motor units in an unconstrained system.

To date, most of the studies exploring the effect of acute muscle vibration on postural control and force generation have been conducted on triceps surae muscles. Previous data have shown that the combination of brief vibratory bursts applied to the tendon of the triceps surae and percutaneous electrical stimulation to the same muscle group could evoke extra self-sustained forces of considerable magnitude.[30] More recently, Spiliopoulou et al[6] found that tendon vibration, applied during isometric tasks, increased the plantar flexion torque (increases between 20 and 30% of the maximal voluntary contraction [MVC]) and agonist muscle activation. In postural control studies, it was also reported that bilateral Achilles tendon vibration induces changes in proprioception resulting in the backward lean of the body with trunk extension, posterior pelvic tilt, and flexion of hips and knees.[31] Although most studies have focused on the effect of triceps surae vibration on postural orientation, specific tasks linked to dimensions of motor control, including goal-directed movements such as pointing, reaching, and aiming, have mainly been studied in the upper limb.[32–36] In a recent study, local vibration applied on erector spinae muscle significantly decreased the accuracy in a trunk extension isometric force reproduction task.[37] The study showed that there was no difference between 30- and 80-Hz vibration stimulation with regard to force production parameters. It remains to be determined if similarities in results between vibration frequencies and decreased sensorimotor control observed during vibration exposure may be influenced by the complex network of paraspinal muscles. Spinal movement and stabilization require complex interactions including intricate control of loading and motion on the different segments and vertebral structures. Therefore, muscle vibration effects may not only operate through the well-documented alteration of muscle spindles afferent activity.

The aims of the present study were (1) to determine whether or not the application of vibration alters the control of soleus isometric force production and (2) to compare present findings with previous work conducted on trunk muscle. The results of this fundamental study will help clarify the role of vibration in the improvement or the disruption of sensorimotor control related to lower limb monoarticular muscles, while specifying the vibration parameters most likely to create the desired changes. Such information is relevant to the broader question of how muscle spindles signal force production of a postural and antigravity muscle during isometric contractions under vibration influence. In this study, the hypothesis that soleus muscle vibration disrupts motor control, making it less accurate and more inconsistent during an isometric force reproduction task, was tested.

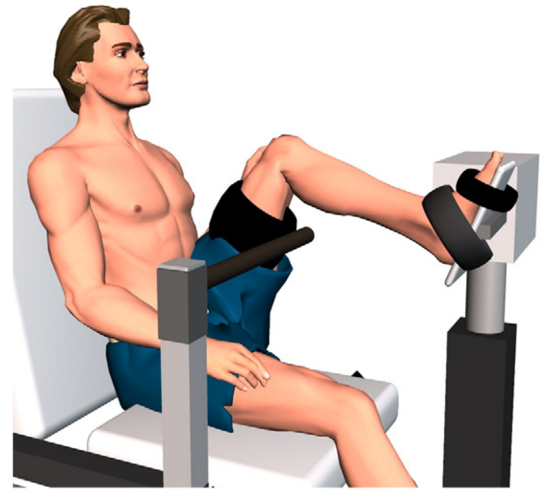

Fig 1. *Testing position with the ankle in a neutral position with and without mechanical vibration. (Color version of figure is available online.)*

Methods

Study Participants

For this study, 20 healthy and active voluntary participants, 11 men and 9 women, ranging in age from 22 to 28 years (mean age, 23.5 ± 1.5 years; weight, 65.7 ± 11.8 kg; height, 172.1 ± 8.1 cm), engaged in the testing. All participants were recruited from the Université du Québec à Trois-Rivières student population. Written informed consent was provided by the participants, and they were fully advised of the procedures. The experimental procedures were approved by the Université du Québec à Trois-Rivières Ethics committee. Exclusion criteria were any acute sprain of the knee/ankle, stress fracture, neuromuscular disorder, inflammatory arthritis, history of knee/ankle surgery, and coagulation disorder.

Dynamometer Device

Force data (torque) in plantar flexion were obtained from an isokinetic device (The LIDO Active; Loredan Biomedical, West Sacramento, CA) used in the isometric testing mode with the setup shown in Figure 1. Testing was performed in a sitting position, the left knee flexed at 90° to limit activation of the gastrocnemius muscles. The ankle was held in place with 2 straps. The hip was also flexed and supported to ensure that participants correctly perform soleus contractions, avoiding knee extension. In biomechanics and functional anatomy, there are marked differences in the action of mono- and polyarticular muscles.

Download English Version:

https://daneshyari.com/en/article/2620626

Download Persian Version:

https://daneshyari.com/article/2620626

Daneshyari.com