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Attenuation of the evoked responses with repeated exposure to proprioceptive disturbances is muscle specific

Sébastien Caudron [a], Lucas Langlois [b], Vincent Nougier [c], Michel Guerraz [a,*]

[a] Laboratoire de Psychologie et de NeuroCognition, UMR 5105 CNRS–Université de Savoie, BP 1104, 73011 Chambéry Cedex, France
[b] Laboratoire de Physiologie de l'exercice. Université de Savoie, 73376 Le Bourget du lac, France
[c] Laboratoire TIMC-IMAG - Equipe Santé, Plasticité, Motricité, UMR 5525 CNRS–Université Joseph Fourier, Faculté de Médecine, 38706 La Tronche Cedex, France

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ABSTRACT

In response to repetitive proprioceptive disturbances (vibration) applied to postural muscles, the evoked response has been shown to decrease in amplitude within the first few trials. The present experiment investigated whether this attenuation of the response to vibration stimulation (90 Hz, 5 s) was muscle specific or would be transferred to the antagonist muscles. Sixteen participants stood upright with eyes closed. One half of the participants practiced 15 tibialis vibrations followed by 15 calf vibrations (TIB-CALF order), while the other half practiced the opposite order (CALF-TIB order). Antero-posterior trunk displacements were measured at the level of C7 and centre of foot pressure (COP). EMG activity of the tibialis anterior (TA) and gastrocnemius lateralis (GL) was also measured. Results showed that evoked postural responses as well as EMG activity decreased with practice when vibration was applied to either calf or tibialis muscles. However, such attenuation of the response appeared muscle specific since it did not generalise when the same vibration stimulus was later applied onto the antagonist muscles.

1. Introduction

In order to limit the likelihood of balance loss, the postural control system has to continuously adapt to biomechanical or sensory varying conditions encountered in everyday life. Such behaviour can be experimentally objectivised when subjects are submitted to sensorial disturbances [1–8]. Whatever the channel manipulated, healthy subjects respond usually quite intensively to the first unexpected sensory disturbance. Responses appear sensibly reduced on subsequent stimulation [3,6,9,10]. However, despite their apparent similarity, attenuation of postural response to repeated disturbances are restricted to the sensory modality of the disturbance and do not transfer automatically to other sensory conditions [8].

Whatever the sensory stimulation (visual, vestibular, proprioceptive) postural responses appear directionally specific [3,11–16]. For instance, vibration applied to either the tendon or the belly of any muscle involved in postural adjustments gives rise to compensatory postural responses, which direction, size or speed depend on the location of the vibrators [17–19]. When vibration is applied to the Achilles tendons, muscle spindles of the calf-muscles (gastrocnemius and soleus) respond as if stretched, that is, as if a standing person is swaying forward. In response, subjects sway backward to balance the simulated forward sway [20]. Conversely, tibialis vibration causes subjects to sway forward.

An important question is whether response attenuation to sensory disturbances can be transferred to similar sensory disturbances but inducing oppositely directed postural responses. Tendon-muscle vibration technique was used in the present experiment to assess this intra-modality transferability. Subjects were submitted to repeated vibration trials applied to either tibialis or calf muscles. Afterwards, they were vibrated on the opposite side, the calf muscles if previously vibrated at the level of the tibialis or vice versa. The purpose was to investigate whether adaptation to stimulation applied to one particular muscle, either the tibialis or the calf muscles could be transferred to its antagonist.

2. Method

2.1. Participants

Sixteen participants (5 females and 11 males, 21.4 years ±3.2; weight $m = 64.5$ kg and height $m = 172$ cm) took part in the experiment and gave their informed consent prior to the study. They had no history of balance or neuromuscular disorders. None of them had ever experienced muscle vibration. This experiment was approved by the local ethics committee and was performed in accordance with the Helsinki Declaration of 1975.

* Corresponding author. Tel.: +33 4 79 75 91 86; fax: +33 4 76 82 78 34.
E-mail address: michel.guerraz@univ-savoie.fr (M. Guerraz).

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2.2. Vibratory stimulation

Two pairs of inertial vibrators (VB115, Techno Concept, France) were attached to the ankle with elastic straps both on the tibialis (over the bellies of both tibialis muscles) and Achilles tendons (Fig. 1). Vibration was applied bilaterally to one of these two pairs of muscles (tibialis vs. calf muscles) for 5 s (90 Hz, 0.85 mm).

2.3. Procedure

Before the experiment, participants were stimulated in a seated position to avoid startle reaction to the vibratory stimuli. Then, participants were instructed to stand still and relaxed, hands at their side, feet in a natural position (10 cm apart) and with eyes closed. The experiment was divided in two sequences of stimulation differing by the stimulus location. One half of the participants practiced 15 tibialis followed by 15 calf vibrations (TIB-CALF), while the other half practiced the opposite order (CALF-TIB). Each vibratory stimulation was preceded and followed by a short and variable period of quiet stance (between 5 and 15 s). No additional time separated the two phases as the first trial of phase 2 directly followed the last trial of phase 1. The experiment lasted 1 h.

2.4. Data recording

Trunk displacements were recorded with an electromagnetic motion capture system (Polhemus Fastrak^{TM}, USA). The sensor was

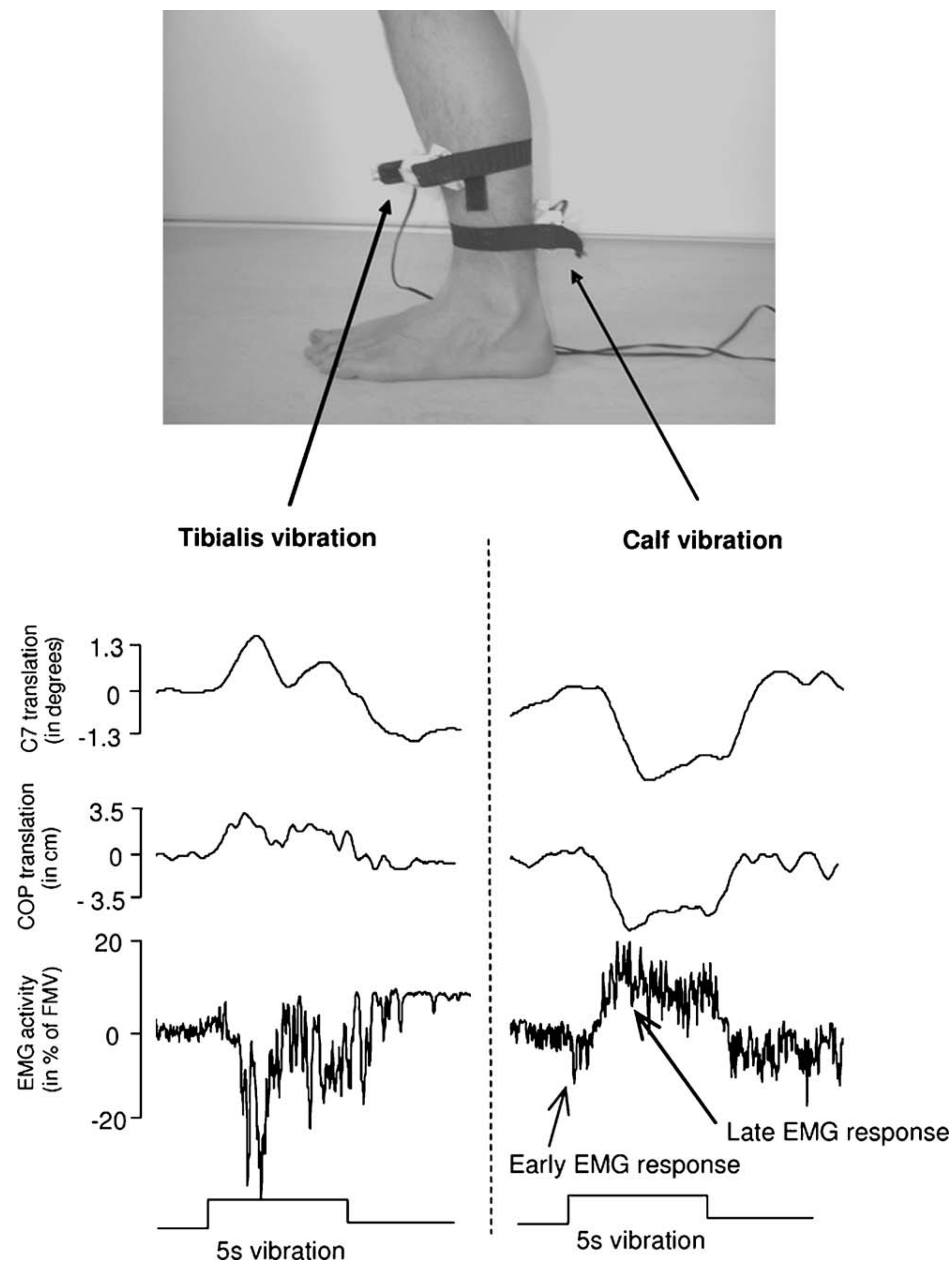

Fig. 1. The photo represents vibrators position. Traces are representative sample antero-posterior postural displacements measured at the level of C7 and COP in response to the first trial of tibialis (left panel) and calf (right panel) vibration. Upward deflection indicates a forward displacement while downward deflection indicates a backward displacement. On the lower panels are represented EMG activities. EMG traces represent the subtraction of gastrocnemius EMG recordings from tibialis recordings. One can notice an early limited agonist (early response) activity followed by a much larger antagonist activity (late response) in both tibialis and calf vibration conditions.