Research Article

Effects of Hand Vibration on Motor Output in Chronic Hemiparesis

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Background. Muscle vibration has been shown to increase the corticospinal excitability assessed by transcranial magnetic stimulation (TMS) and to change voluntary force production in healthy subjects. Objectives. To evaluate the effect of vibration on corticospinal excitability using TMS and on maximal motor output using maximal voluntary contraction (MVC) in individuals with chronic hemiparesis.

Methodology. Nineteen hemiparetic and 17 healthy control subjects participated in this study. Motor evoked potentials (MEPs) and MVC during lateral pinch grip were recorded at first dorsal interosseous muscle in a single session before, during, and after one-minute trials of 80Hz vibration of the thenar eminence.

Results. In hemiparetic subjects, vibration increased MEP amplitudes to a level comparable to that of control subjects and triggered a MEP response in 4 of 7 patients who did not have a MEP at rest. Also, vibration increased the maximal rate of force production (dF/dt_max) in both control and hemiparetic subjects but it did not increase MVC. Conclusion. Motor response generated with a descending cortical drive in chronic hemiparetic subjects can be increased during vibration. Vibration could be used when additional input is needed to reveal motor responses and to increase rate of force generation.

1. Introduction

Results from transcranial magnetic stimulation (TMS) studies support the evidence that hemiparetic subjects have deficits in excitability of the corticospinal pathways [1]. Motor evoked potentials (MEPs) generated by TMS are absent in the vast majority of patients with a severe motor deficit [2, 3]. Moreover, MEP evaluation seems to be helpful in predicting functional recovery after stroke [4].

It is well known that primary spindle endings in muscles are very sensitive to vibration [5, 6]. Microneurographic recordings in healthy human subjects have shown that low-amplitude vibration at a frequency of 80 Hz is an efficient and selective stimulus to trigger Ia afferents activity [6, 7]. Increased amplitude and a decreased latency of the MEP generated by TMS have been observed during vibration [8, 9]. Moreover, there are reports of changes in voluntary force production during and after vibration in healthy [10] and stroke [11] subjects and in motor function in patients with neurological diseases [12, 13]. Thus, in the present study, 80 Hz muscle vibration was applied to explore the use of a strong sensory input to improve motor output in hemiparetic subjects. MEPs and MVC (maximal voluntary contractions) were recorded before, during, and after hand vibration in order to study the influence of vibration on corticospinal excitability while the subject was resting and on maximal voluntary motor output, respectively. The objectives were to compare the effects of vibration between control and chronic hemiparetic individuals and study the persistence of these effects in time and their relationship with motor impairment (Fugl Meyer hand score).

2. Methods

2.1. Subjects. Nineteen hemiparetic subjects (mean SD; 45 ± 13 years at 39 ± 19 months after stroke) and 17 control subjects
(42 ± 13 years) with no history of neurologic disease or injury volunteered to participate in this study. The patients had severe-to-mild hand paresis (Chedoke McMaster hand score 2–7 [14]) and preserved vibration sensibility (≥5 s with 128 Hz tuning fork [15]). All the hemiparetic and control subjects participated in the MVC experiment. Only fourteen patients and 16 control subjects participated in the TMS experiment because they had exclusion criteria for the TMS (epilepsy, medication influencing neuronal excitability, or implanted metal) (Table 1). All participants signed the information and consent form approved by the Research Ethics Committee of the CRIR institutions in Montreal.

2.2. Experimental Protocol. The protocol comprised a single session of approximately 3 hours for clinical and experimental evaluations.

2.2.1. Clinical Evaluations. The perception thresholds of touch-pressure and vibration were tested with the Semmes Weinstein monofilaments [16] and the commercially available MEDOC apparatus, respectively. Proprioception was evaluated as the number of trials correctly perceived during 10 passive displacements in opposite directions at the distal phalanx of the thumb [15]. The hand and digit dexterity were evaluated with the Box and Block (BB) Test [17] and the Nine Hole Peg (NHP) Test [18], respectively. The level of hand motor impairment (maximal score of 24 points, including items for the wrist and hand function) and the spasticity of the arm (maximal score of 16) were evaluated with the Fugl-Meyer (FM) Test [19] and the Composite Spasticity Index (CSI) [20], respectively.

2.2.2. Position. All subjects were comfortably seated on a chair with the backrest tilted 20° backwards and with the forearm and the hand supported (shoulder with 0° of rotation, 40° of abduction, and 30° of flexion; the elbow with 75° of flexion, neutral position for the forearm; wrist with 20° of extension; fingers attached to a strain-gauge in a lateral pinch position of the index and thumb).

2.2.3. Vibration. A cylinder shaped vibrator (Dynatronic VB 100, 3 cm diameter, 7 cm long) was placed on the volar surface of the hand across the thenar eminence, 2 cm from the wrist line to produce whole hand vibration and to facilitate an optimal EMG recording of the first dorsal interosseous (FDI) muscle. The vibratory stimulus of 0.7–0.9 mm amplitude was applied during one-minute periods and repeated 3 times during each experimental protocol (see the stimulation protocol below). The presence of a tonic vibration reflex (TVR) was controlled by the experimenter monitoring the EMG activity. This control aims to avoid the presence of TVR on the EMG recordings that could interfere with the measurement of MEPS. Since TVR can change motoneuronal excitability at the spinal level [21, 22], it might affect both force production and MEPS. Therefore, care was taken to avoid the presence of TVR in all EMG recordings assessed in this study. However, it does not prevent a possible subliminal change of excitability at the spinal level that could be part of the vibration response.

2.3. Experimental Procedure

2.3.1. Protocol 1: The Effects of Hand Vibration on MEPS. Subjects were asked to keep their eyes open and to concentrate on a picture placed in front of them. TMS was performed using a Magstim 200 monopulse stimulator (Magstim Cie, Whales, UK) and a 70 mm double coned coil centered approximately 7 cm lateral to the vertex optimally positioned to obtain a MEP in the FDI. After determining the motor threshold (MT) [23], the hand motor cortex was stimulated, with an intensity of 1.2x MT and a minimum of 15 s interstimulus interval (ISI). MEPS were recorded at rest to investigate changes in corticospinal excitability during vibration without the influence of cortical activation that accompanies voluntary muscle contraction and to minimize between subjects difference in cortical excitability [24]. Moreover, this influence of cortical activation due to voluntary contraction might be different between patients and control subjects since stroke patients are expected to be weaker and more prone to fatigue than control participants [25, 26] and that fatigue can influence MEP measures [27, 28]. EMG recordings from the FDI muscle belly were done with bipolar surface electrodes (1 cm apart). The signals were amplified, filtered (30 Hz to 1 kHz), digitized at 3 kHz, and recorded on a hard disc for off-line analysis. An experimental trial consisted in EMG recordings that started 100 ms before and ended 200 ms after a TMS stimulation. After finding the hotspot and MEP threshold, a total of 40 MEPS were recorded for each participant.

MEPs amplitudes (peak to peak) and latencies obtained in the FDI target muscle were compared in 5 different experimental conditions before (C1), during (C2), and after (C3, C4, and C5) vibration at the time intervals presented in Figure 1(a).

2.3.2. Protocol 2: The Effect of Vibration on the Maximal Voluntary Force in Lateral Pinch. After an auditory signal, subjects had to produce a MVC, as fast as possible for 3-second duration, using a pinch grip opposing the lateral aspect of the index finger and the thumb. A strain-gauge, mounted on a metal bridge placed between the two fingers, was used to monitor and record the force exerted. Recordings of a trial started 1 s before and ended 4 s after the auditory signal.

The maximal force exerted during MVC, the maximal rate of force development (dF/dtmax, calculated from the derived force curve and equivalent to the speed of maximal force generation), and the integrated EMG signals of FDI (analysed during 500 ms centred on the peak of the force) were compared in 4 different experimental conditions before (C1), during (C2), and after (C3 and C4) vibration at the time intervals presented in Figure 1(b). Intertrial intervals (ITI) between each contraction were of 2-minute duration to prevent fatigue.

Protocols were applied in a random order with an interval of 30 minutes between each one.

2.4. Data Analyses and Statistics. After testing for equality of variances (Levene test), nonparametric statistics were used to analyze the data for MEP and MVC. The Mann-Whitney
Table 1: Characteristics and clinical evaluations of the hemiparetic subjects.

<table>
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<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Hemi. side</th>
<th>Lesion location</th>
<th>Time since AVC (months)</th>
<th>FM hand (0–24)</th>
<th>SW 128 Hz tuning fork (s)</th>
<th>VT (μ)</th>
<th>PP (0–10)</th>
<th>Spasticity index (0–16)</th>
<th>BB Hemi. side</th>
<th>NHP Hemi. side</th>
<th>MT (%)</th>
<th>MEP rest (μV)</th>
<th>MEP vib (μV)</th>
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*Bold numbers: < 2.5 SD> mean control values.

FM, Fugl-Meyer; M, male; F, female; R, right; L, left; SW, Semmes Weinstein; VT, vibration threshold; PP, proprioception; BB, Box and Block; NHP, Nine Hole Peg; MT, motor threshold; MEP rest, average amplitude of motor evoked potential at rest (before vibration, C1); MEP vib, average amplitude of motor evoked potential during vibration (C2); MVC, average maximal voluntary contraction during a pinch lateral grip force; NA, not able; NR, no response; Exc, excluded for TMS protocol.
test and the Wilcoxon test were used to compare these variables between groups and across the different experimental conditions within each group, respectively. Moreover, the nonparametric Spearman rank correlation coefficient was used to evaluate the relationship of MEP's amplitudes and maximal force results with those of the clinical evaluations.

For the MEPs amplitude and latency values, the trials were averaged within each experimental condition after statistical analysis showed that there were no differences between trials within these time windows, thus confirming that there was no significant effect produced by the repetition of the TMS stimulus, the 15 s intertrial interval or the repetition of the vibration. The trials of the maximal force, within each of the 4 experimental conditions in the second protocol, were averaged as well after statistical analysis confirmed that there was no difference between the 3 MVC within the same experimental condition. However, this was not the case for the $dF/dt_{max}$ since this variable was influenced by the repetition of the vibration as will be shown in the MVC results.

### 3. Results

Table 1 shows the demographic data of the 19 hemiparetic patients. The order of presentation from top to bottom corresponds to the Fugl Meyer (FM) score of hand function from the most (0) to the least involvement (24). It can be observed that subjects which are unable to do the BB and the NHP tests have a FM score ≤ 4 and ≤ 17, respectively. Notice that the only patient with a FM > 17 that was unable to perform the NHP (patient #12) presented an important sensory deficit.

#### 3.1. MEPs Results

Reproducible motor responses could be generated at rest in all control subjects with an average MT of $37 ± 2\%$ (Mean ± SEM) of the maximal stimulator output. However, MEPs were absent in half of the patients ($n = 7/14$) at rest, even when tested with a stimulation intensity of 100% of the maximal stimulator's output. All of these patients with absent MEPs had a poor motor recovery level as indicated by a FM hand score ≤ 16 (Table 1). However, a MEP response could be produced in the FDI of 4 of these 7 patients during vibration (e.g., Figure 2(a), bottom trace) without appearance of a TVR. For the 7 other patients presenting MEPs at rest before vibration, MT ($40 ± 3\%$) were not significantly different from those of the control subjects. Mean MEP latencies in the FDI at rest before ($24.7 ± 0.8$ ms), during ($24.0 ± 0.7$ ms), and after vibration ($24.7 ± 0.7$ ms) in the patients were longer ($P = 0.04$) than in the control subjects ($22.9 ± 0.5$ ms, $22.2 ± 0.5$ ms, and $22.7 ± 0.6$ ms, resp.). Moreover, MEP's latencies decreased during vibration in both control ($P = 0.04$) and hemiparetic ($P = 0.03$) subjects.

The typical behaviors of the MEPs responses in a control and a hemiparetic subject are presented in Figure 2(a). Before vibration, the averaged MEP amplitude of the patients was about half the size of that of the control subjects. However, the difference between the groups was not significant because of the large intersubject variability in the patients (range: 60–765 μV) and particularly in the control subjects (range: 73–3209 μV) where the amplitude reached high values in some subjects as soon as the intensity was raised above MT. While vibration increased ($P = 0.04$) MEP amplitudes by an average close to 50% of previbration amplitudes in control subjects (range: 161–4090), it more than doubled the size of the MEPs responses in the patients ($n = 4/7$) increasing it ($P = 0.018$) to an average amplitude (range 70–1896) similar to that of
3.2. MVC Results. Before vibration, 8 of the 10 subjects with a FM score ≥18 could produce a lateral pinch force above 40 N during MVC, while none of the subjects with a FM score ≤17 could reach that strength level (Table 1). On average, hemiparetic subjects had smaller (P = 0.003) maximal lateral pinch force (LPF) (38 ± 6 N, range 5–93 N) than control subjects (66 ± 4 N, range 40–93 N) before vibration. This difference was maintained throughout the experimental conditions as vibration did not influence LPF in either group.

\( \frac{dF}{dt_{\text{max}}} \) was also smaller (P = 0.001) in the patients than in the control subjects and was influenced by the vibration (P = 0.03) and the number of vibration trials in both groups (P = 0.04) particularly in the hemiparetic subjects. In the control subjects, the first vibration trial had no significant effect on the \( \frac{dF}{dt_{\text{max}}} \) (Figure 3). However, the \( \frac{dF}{dt_{\text{max}}} \) increased in the second trial and maintained this enhancement in the third trial producing a significant (P < 0.05) 14% increase compared to the previbration trials. In the hemiparetic subjects, the vibration generated a stronger (P < 0.01) relative increase (31%) on the \( \frac{dF}{dt_{\text{max}}} \) compared to the previbration condition and the effect gradually increased with additional vibration trials. Hence, in the third vibration trial, the patients were able to reach their peak force faster than in the first two vibration trials. Despite this increase, the \( \frac{dF}{dt_{\text{max}}} \) of the patients did not reach the values of the control subjects and these effects did not persist after the end of the vibration in either group (Figure 3).

3.3. Relationships between Motor Responses and Clinical Tests. Before and during vibration, amplitudes of MEPs in the FDI were correlated with maximal LPF and \( \frac{dF}{dt_{\text{max}}} \) values (Table 2). As expected, there were strong correlations between the \( \frac{dF}{dt_{\text{max}}} \) and LPF. These three motor output measures (i.e., MEP, LPF, and \( \frac{dF}{dt_{\text{max}}} \)) were not correlated with the results of the sensory tests. On the other hand, the three motor output measures were correlated with levels of
MVC control subjects. Indeed, even the MEPs of these patients had a longer latency and smaller amplitude than those of control subjects. In hemiparetic patients, this increase in latencies was already reported [30].

Previous studies have shown that vibration increases MEP amplitudes in the vibrated muscle of healthy subjects [8, 9, 30]. While our results show an increase of 50% in the control subjects, the effect of vibration was much stronger in the hemiparetic patients where it more than doubled the amplitude of the MEP responses. Although this could be the result of a facilitation at the spinal level, results of other studies indicate that vibration increases cortical excitability. In healthy subjects, Kossev et al. [9] showed that muscle vibration (80 Hz) caused an increase in MEPs amplitude following TMS but not following transcranial electrical stimulation (TES), indicating an increased excitability of the cortical neurons and not directly of the corticospinal pathway. Moreover, Rosenkranz et al. [30] reported that muscle vibration at 80 Hz decreases the intracortical inhibition and increases the intracortical facilitation produced by paired TMS stimulation.

In patients where a MEP could be triggered at rest without extra sensory stimulation (i.e., without vibration), MT were not significantly different than those of control subjects. This suggests that they have enough cells with a normal excitability level that can produce a minimal motor response. However, the MEPs of these patients had a longer latency and smaller amplitude than those of control subjects. In hemiparetic patients, this increase in latencies was already reported [30] and could indicate a delay in the neurons recruitment, in the transmission through the corticospinal pathway or a synaptic inefficacy. Vibration was not efficient to abolish this delay in

### Table 2: Spearman correlation coefficients of motor output versus motor function and sensory evaluation.

<table>
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<tr>
<th>Tests</th>
<th>MEP amplitude Before vibration</th>
<th>During vibration</th>
<th>MVC Before vibration</th>
<th>During vibration</th>
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<td>0.71&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.68&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.69&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.96&lt;sup&gt;†&lt;/sup&gt;</td>
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<td>0.90&lt;sup&gt;‡&lt;/sup&gt;</td>
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<td>Spasticity and hand function</td>
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<tr>
<td>FM hand</td>
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<td>0.81&lt;sup&gt;†&lt;/sup&gt;</td>
<td>0.74&lt;sup&gt;‡&lt;/sup&gt;</td>
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<td>Spasticity</td>
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<tr>
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<td>−0.08</td>
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MEP: motor evoked potential; MVC: maximal voluntary contraction; dF/dt<sub>max</sub>: maximal rate of force production; FM: Fugl-Meyer; BB: Box and Block; NHP, Nine Hole Peg. Correlations with MEP: n = 14; correlations without MEP: n = 19.

*P < 0.05; †P < 0.01; ‡P < 0.001.

hand impairment (FM), hand coordination (BB and NHP), and spasticity levels measured before and during vibration.

### 4. Discussion

This study is the first, to our knowledge, to test the effect of vibration on corticospinal excitability and maximal force production after a stroke and moreover to correlate these motor output measures with clinical measures. It shows that a single session of muscle vibration can increase the amplitude of motor potentials evoked by TMS at rest and it can raise the rate of force change during maximal voluntary contraction.

#### 4.1. MEP Responses and Vibration Effects in Hemiparetic and Control Subjects

As shown previously [2, 3, 29], MEPs could not be obtained in several subjects after stroke. Interestingly, lack of MEPs responses at rest was found in the patients with poor recovery levels (all patients with a FM score <17/24), the lowest hand function scores, and the highest spasticity levels. In these cases, the lack of responses after motor cortical stimulation points out to a loss of a large number of motor cortical neurons or a strong decrease in the motor neurons excitability levels. The results show that vibration can trigger the appearance of MEPs in the FDI in more than half of the hemiparetic subjects that had no response prior to vibration. In these cases neurons needed an extra peripheral input to facilitate their excitability levels. Moreover, it increases the MEPs amplitudes observed in other patients with less motor impairments. This means that vibration is a good tool to potentiate motor response in otherwise nonresponsive patients and increase motor output.

Previous studies have shown that vibration increases MEP amplitudes in the vibrated muscle of healthy subjects [8, 9, 30]. While our results show an increase of 50% in the control subjects, the effect of vibration was much stronger in the hemiparetic patients where it more than doubled the amplitude of the MEP responses. Although this could be the result of a facilitation at the spinal level, results of other studies indicate that vibration increases cortical excitability. In healthy subjects, Kossev et al. [9] showed that muscle vibration (80 Hz) caused an increase in MEPs amplitude following TMS but not following transcranial electrical stimulation (TES), indicating an increased excitability of the cortical neurons and not directly of the corticospinal pathway. Moreover, Rosenkranz et al. [30] reported that muscle vibration at 80 Hz decreases the intracortical inhibition and increases the intracortical facilitation produced by paired TMS stimulation.

In patients where a MEP could be triggered at rest without extra sensory stimulation (i.e., without vibration), MT were not significantly different than those of control subjects. This suggests that they have enough cells with a normal excitability level that can produce a minimal motor response. However, the MEPs of these patients had a longer latency and smaller amplitude than those of control subjects. In hemiparetic patients, this increase in latencies was already reported [30] and could indicate a delay in the neurons recruitment, in the transmission through the corticospinal pathway or a synaptic inefficacy. Vibration was not efficient to abolish this delay in
the patients compared to the latency values in the control subjects, but it shortens the latencies by an average of 0.7 ms in both groups. Other investigators have also found that vibration can decrease MEP latency by an average of 0.9 ms in healthy [8, 9] and hemiparetic [31] subjects.

4.2. Effects of Vibration on Force Output. Vibration in our experiment had no effect on MVC (i.e., maximal LPF) in control and in hemiparetic subjects. These results in the healthy subjects are in agreement with those of Bongiovanni and Hagbarth [32] demonstrating that a single session of vibration increases strength only in fatigued muscles. Also, the iEMG of the FDI (a muscle strongly solicited in that task) was also unchanged. This brings further evidence that maximal motor output was not influenced by vibration and that no muscle fatigue was produced. It is possible that vibration could not increase FDI EMG level because it was already at maximal output during MVC.

Vibration did not increase strength but it increased the \( \frac{dF}{dt_{\max}} \) indicating that the maximal force was reached more rapidly. This effect was stronger in the patients than in the control subjects and it increased with the number of vibration trials, supporting the notion that additive effects could occur with repeated vibration. The fact that \( \frac{dF}{dt_{\max}} \) increased with the number of vibration trials only in the vibrated condition (and not in the other conditions before or after vibration) further supports that the effect is due to the repetition of the vibration and not to an unspecific habituation effect simply caused by the repetition of the effort. The increase of the \( \frac{dF}{dt_{\max}} \) without an increase in maximal force indicates that vibration produced a higher recruitment of motoneurons in the initial phase of the voluntary contraction without increasing the total number of motoneurons recruited at peak force. This could correspond to a higher firing rate, a faster spatial summation in the initial phase, or even a change in the recruitment order of the motoneurons whereby larger motoneurons are recruited sooner.

Vibration induced facilitation of the motor responses is probably of proprioceptive origin in reaction to muscle spindle stimulation. Bongiovanni and Hagbarth [32], using a local anaesthetic agent for attenuating \( \gamma \)-loop function, have suggested that spindle feedback would be important to generate the high motor unit firing rates in the initial phase of a MVC. It was shown that 80 Hz muscle vibration is the optimal frequency to excite Ia afferents [6] and to increase MEPs amplitudes [8, 33]. Furthermore, the behavior of these muscle afferents could explain why the effects did not persist beyond the vibration period since Ia afferents have been shown to stop firing at the end of the vibration [5, 6]. In these circumstances, it is probable that the small number of vibration trials used in our experiment (only 3) did not permit a learning effect that could have persisted beyond the vibration period.

While some investigators report an increase in voluntary force production during and after vibration in fatigued muscles of healthy subjects [34], other studies using much longer vibration time (i.e., 30 minutes; 30 Hz) showed a decrease in the force specifically in the vibrated muscle [35]. Moreover, segmental vibration has been shown to increase the activation of the tibialis anterior muscle on the paretic side [12]. However, vibration effects are complex. Besides duration of vibration, differences between studies could be due to other parameters of vibration (e.g., frequency, amplitude), experimental design (e.g., single session versus training), and a different muscular state (e.g., muscle fatigue). The present study only reveals that vibration has the potential to increase motor output in hemiparetic patients. However, our results are in accordance with the mechanisms of strengthening techniques where spatial recruitment would come first and later training could increase motor units size and muscle hypertrophy thereby increasing strength.

4.3. Relations between Motor Output and Clinical Evaluations. Heald et al. [36] demonstrated that patients with preserved MEP at rest had a more complete return of function and patients with absent MEP at rest were at high risk of a poor functional recovery. To confirm these observations, our results revealed that there is a strong relationship between the amplitude of the MEPs response and the Fugl-Meyer score of hand impairment. Moreover, MEPs amplitudes were also strongly correlated with specific tests of hand function such as the BB and the NHP. However, it is not the only predictor of hand function. Other factors such as coordination, spasticity levels, and sensibility should also be considered.

There is a positive correlation between MEP amplitude and MVC both before and during vibration. While MEP amplitude is a direct measure of corticospinal excitability following passively induced activation of the cortex by the experimenter’s stimulus (i.e., TMS), these correlations suggest that MVC following voluntary activation of the cortex by the subject also reflect, at least in part, corticospinal excitability.

Motor outputs during the MVC task and MEPs amplitudes before vibration were related to hand motor impairment and functions but not to the sensory tests results. These results suggest that motor deficit is the most important factor to explain the functional deficit assessed by these outcomes. However, there was no correlation between the sensory and motor tests results. This is possibly because patients with decreased sensibility compensated with visual feedback to execute the hand motor tasks. Studies with deafferented patients have shown the striking difference in hand motor performance with and without vision [37, 38]. However, vision cannot compensate entirely for severe proprioceptive deficits. The three patients with no proprioception in the thumb, independently of their level of motor recovery, were not able to execute the fine motor test and had also a poor score in the gross motor test, even using visual feedback.

In conclusion, the ensemble of findings has impacts in stroke rehabilitation. Vibration could be used when additional input is needed to reveal motor responses and to increase rate of force generation when training weak patients. Future researches should answer if different vibration procedures, including repeated stimulations and training, could increase maximal force output and motor function and if these effects could persist after vibration. Furthermore, it should also be investigated by which neural mechanisms,
cortical and/or spinal, vibration effects are mediated in hemiparetic subjects.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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