Chapter 2

Characteristics of the F-Wave and H-Reflex in Patients with Cerebrovascular Diseases: A New Method to Evaluate Neurological Findings and Effects of Continuous Stretching of the Affected Arm

Toshiaki Suzuki, Tetsuji Fujiwara, Makiko Tani and
Eiichi Saitoh

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/55887

1. Introduction

The F-wave is a result of the backfire of α-motoneurons following an antidromic invasion of propagated impulses across the axon hillock (Kimura, 1974). Its occurrence reflects excitability changes in the spinal motor neurons, as reported in patients with spasticity (Odusote & Eisen, 1979) and in healthy subjects with isometric contraction (Suzuki, Fujiwara & Takeda, 1993). In our previous study that investigated the nervous system of hemiplegic patients, excitability of spinal neural function was evaluated using F-wave data of patients with cerebrovascular disease (CVD) (Suzuki, Fujiwara & Takeda, 1993). We also reported that the persistence and amplitude ratio of F/M in patients with CVD were affected by the grade of muscle tonus, tendon reflex, or voluntary movement. Persistence reportedly depends on the number of neuromuscular units activated, while the amplitude ratio of F/M depends on their excitability (Eisen and Odusote, 1979). Therefore, we concluded that F-wave measurement was an effective neurological test for evaluating muscle tonus and voluntary movements.

Generally, current stimulus intensity required to generate an F-wave is 20% more than that required to generate a supramaximal M-wave because only the F-wave appears in healthy subjects; the H-reflex that is elicited by electrical stimulation of a peripheral mixed nerve, especially muscle spindle Ia fibers, does not appear in healthy subjects. However, we observed that the H-reflex could be evoked with supramaximal stimulation, a test for measuring the F-wave in CVD patients with hypertonus and hyperreflexia. As a result, the H-reflex can be mistaken for an F-wave during F-wave measurement using supramaximal stimulation.

We hypothesized that evaluation of F-wave and H-reflex patterns resulting from increased stimulus intensity in CVD patients could be a potential new method for the neurological evaluation of the affected arm or leg. In this report, we investigated the excitability of spinal neural function by evaluating H-reflex and F-wave patterns resulting from increased stimulus intensity during muscle relaxation in healthy subjects and CVD patients. The results were analyzed in terms of the characteristic appearance of the H-reflex and F-wave in the healthy subjects and the relationship between the neurological findings of CVD and the characteristic appearance of the H-reflex and F-wave in the CVD patients.

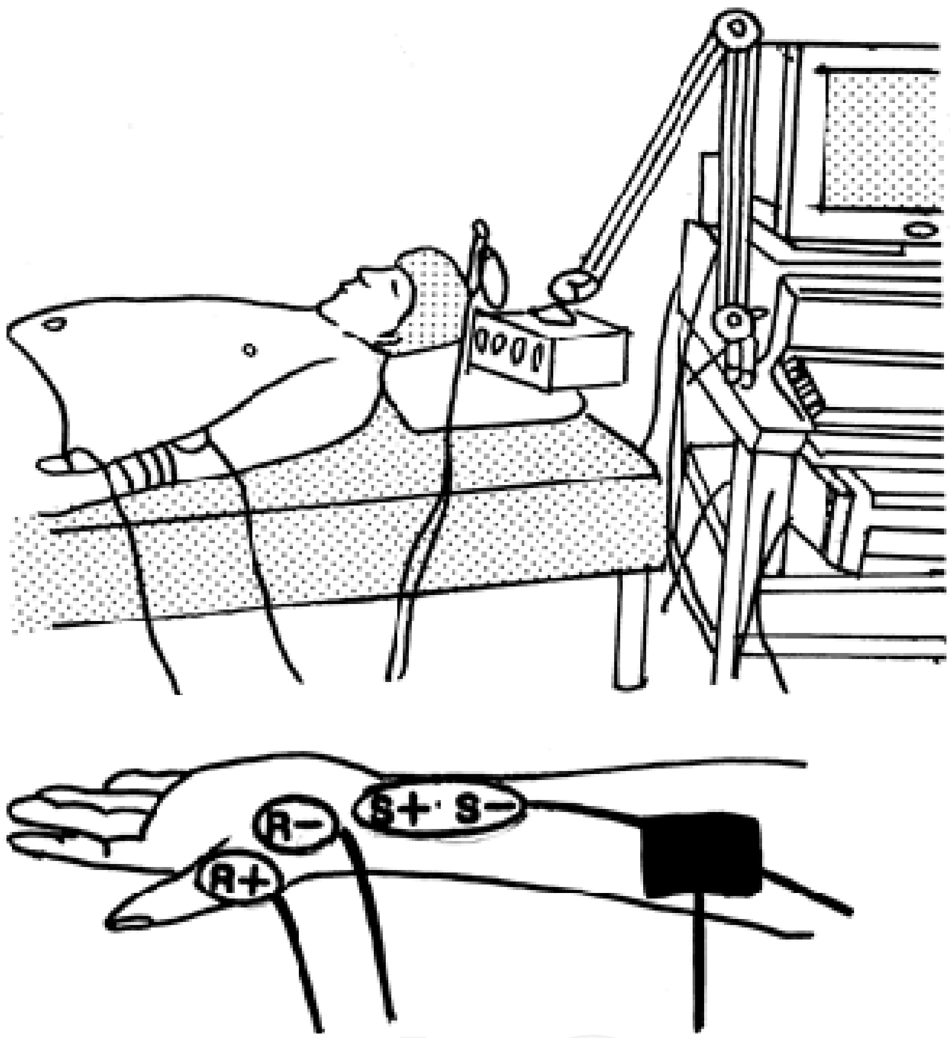
In the field of rehabilitation medicine, muscle stretching is generally used to increase range of motion and improve muscle tonus. The effects of leg muscle stretching have been previously evaluated using H-reflex data (Angel et al., 1963 and Nielsen et al., 1993), and the results showed that the H-reflex following passive stretching was decreased to a lesser extent in spastic patients than in healthy subjects. However, in that study, the calf muscles and not the arm muscles were stretched; moreover, the periods of continuous stretching were different.Therefore, we also investigated the effects of continuous stretching of the affected arm for 1 min by evaluating H-reflex and F-wave characteristics in different stretched arm positions in the CVD patients.

2. Characteristics of H-reflex and F-wave patterns resulting from increased stimulus intensity during muscle relaxation

The H-reflex and F-wave of the affected arm were examined under conditions of increased stimulus intensity during muscle relaxation in 31 patients (17 male and 14 female) with hemiplegia caused by CVD. The mean patient age was 56 years (range: 30–82 years). Eighteen patients had cerebral infarction (7 with right and 11 with left hemiplegia) and 13 had cerebral hemorrhage (7 with right and 6 with left). The control group included 30 healthy subjects with a mean age of 56.2 years (range: 28–80 years). Written informed consent was obtained from all subjects. The experiments were conducted in accordance with the Declaration of Helsinki, and no conflicts of interest were declared by the authors.

Examination was performed in a supine, relaxed position. H-reflex and F-wave data under conditions of increased stimulus intensity following median nerve stimulation at the wrist were recorded at the opponens pollicis muscle, which was in a relaxed state, of the affected arm of the CVD patients or the right arm of the healthy subjects (Fig 1). The stimulus frequency was 0.5 Hz and the stimulus duration was 0.2 ms. H-reflex and F-wave patterns that resulted from increased stimulus intensity were divided into 4 types (types 1–4).

http://dx.doi.org/10.5772/55887



R+: Recording Electrode (+), R−: Recording Electrode (−)
S+: Stimulating Electrode (+), S−: Stimulating Electrode (−)

Figure 1. Measurement of the H-reflex and F-wave

In type 1, the F-wave appeared with increased stimulus intensity, but there was no H-reflex (Fig 2). The F-wave pattern for the upper arm, especially the distal portion in healthy subjects, roughly indicated a type 1 pattern. In type 2, the H-reflex and F-wave both appeared with increased stimulus intensity, but the F-wave followed the disappearance of the H-reflex (Fig 3). In type 3, the H-reflex and F-wave both appeared with increased stimulus intensity, but the F-wave appeared during the H-reflex (Fig 4). In type 4, only the H-reflex appeared with increased stimulus intensity; there was no F-wave (Fig 5).

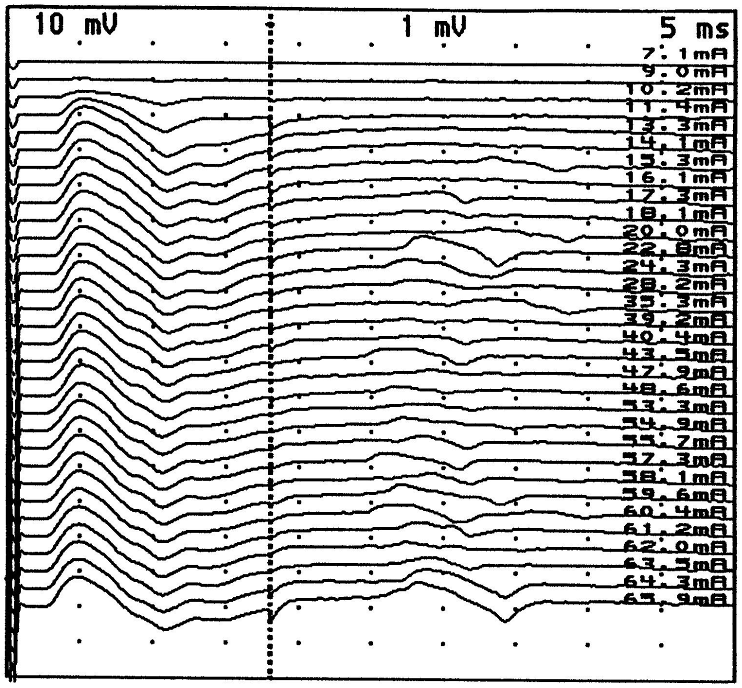


Figure 2. H-reflex and F-wave patterns resulting from increased stimulus intensity (Type 1) The F-wave appeared with increased stimulus intensity, but there was no H-reflex.

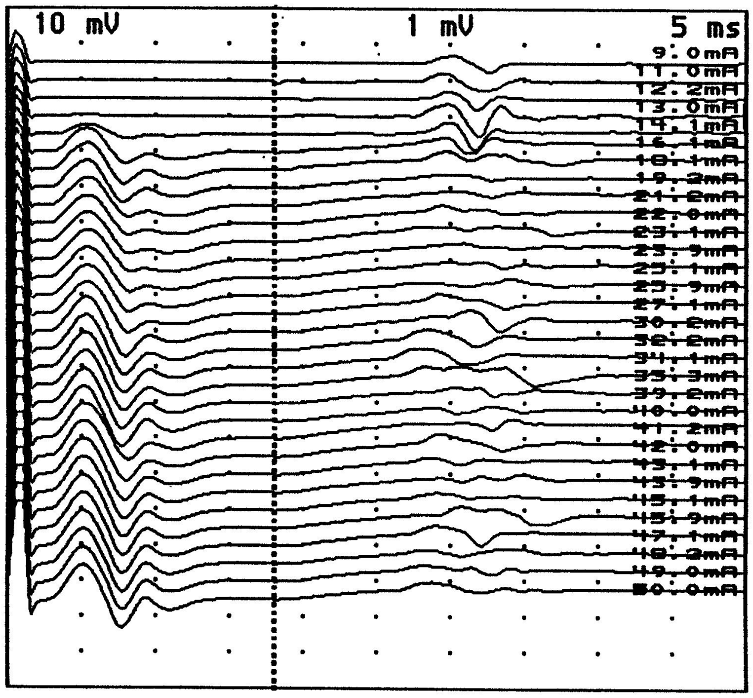


Figure 3. H-reflex and F-wave patterns resulting from increased stimulus intensity (Type 2) The H-reflex and F-wave both appeared with increased stimulus intensity, but the F-wave followed the disappearance of the H-reflex.

http://dx.doi.org/10.5772/55887

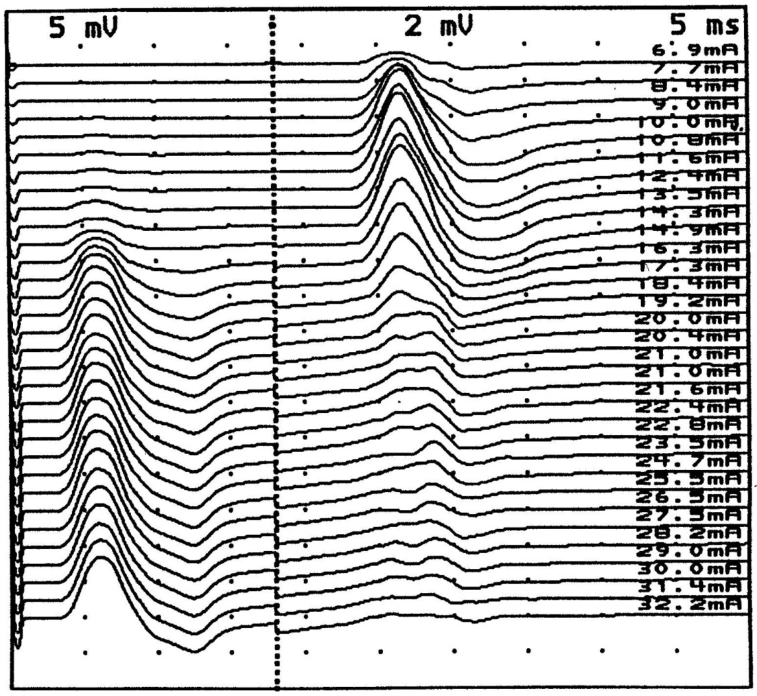


Figure 4. H-reflex and F-wave patterns resulting from increased stimulus intensity (Type 3) The H-reflex and F-wave both appeared with increased stimulus intensity, but the F-wave appeared during the H-reflex.

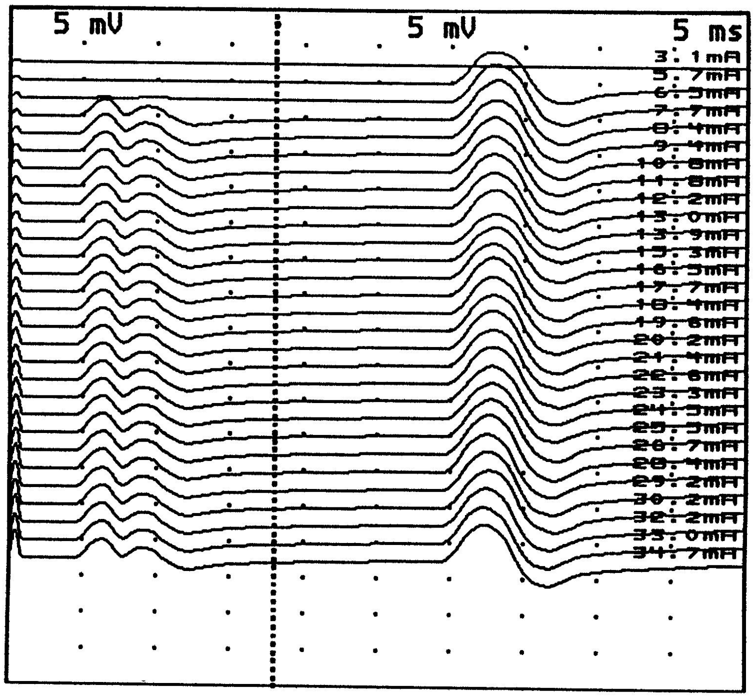


Figure 5. H-reflex and F-wave patterns resulting from increased stimulus intensity (Type 4) Only the H-reflex appeared with increased stimulus intensity, but there was no F-wave.

Neurological findings, including muscle tonus and tendon reflex, were also evaluated. Findings of muscle tonus and tendon reflex were classified into increased (markedly, moderately, and slightly), normal, and decreased.

The results were analyzed in terms of the characteristic appearance of the H-reflex and F-wave in the healthy subjects and the relationship between the neurological findings of CVD and the characteristic appearance of the H-reflex and F-wave in the CVD patients.

H-reflex and F-wave patterns resulting from increased stimulus intensity were type 1 in all healthy subjects. The relationship between H-reflex and F-wave patterns resulting from increased stimulus intensity and the neurological signs of CVD is shown in Tables 1 and 2. H-reflex and F-wave patterns resulting from increased stimulus intensity in patients with markedly increased muscle tonus and tendon reflex were most frequently type 4 patterns, those in patients with moderately increased muscle tonus and tendon reflex were type 2 or 3 patterns, those in patients with slightly increased muscle tonus and tendon reflex were type 1 or 2 patterns, and those in patients with normal or decreased muscle tonus and tendon reflex were type 1 patterns.

	Increased			Normal	Decreased
	Markedly	**Moderately**	**Slightly**		
Type 1	0	0	2	5	3
Type 2	0	4	4	0	0
Type 3	2	4	1	0	0
Type 4	5	1	0	0	0

The number of subjects was 31 (Type 1: 10, Type 2: 8, Type 3: 7, Type 4: 6)

Table 1. The relationship between H-reflex and F-wave patterns resulting from increased stimulus intensity and muscle tonus

	Increased			Normal	Decreased
	Markedly	**Moderately**	**Slightly**		
Type 1	0	0	1	6	3
Type 2	0	3	5	0	0
Type 3	2	4	1	0	0
Type 4	4	2	0	0	0

The number of subjects was 31(Type 1: 10, Type 2: 8, Type 3: 7, Type 4: 6)

Table 2. The relationship between H-reflex and F-wave patterns resulting from increased stimulus intensity and tendon reflex

These results indicated that the H-reflex, and not the F-wave, appeared with supramaximal stimulation in patients with a relative increase in excitability of spinal neural function. Furthermore, the neurological signs of muscle tonus and tendon reflex affected H-reflex and F-wave patterns in the CVD patients. These H-reflex and F-wave patterns were therefore used for the neurological evaluation of the CVD patients.

3. Characteristics of the H-reflex and F-wave in different stretched arm positions in the CVD patients

3.1. The effects of continuous stretching of the affected arm (the H-reflex study)

Ten hemiplegic patients (4 male and 6 female) with hypertonus caused by CVD were tested. The mean patient age was 53.2 years (range: 34–63 years). There were 5 patients with cerebral hemorrhage (2 with right and 3 with left hemiplegia) and 5 with cerebral infarction (2 with right and 3 with left hemiplegia). The cortical location of the lesion, as verified by brain computed tomography, was temporal in 4 patients, parietal in 2, and temporo-occipital in 2. The lesion was located in the brain stem in the remaining 2 patients. Patients were divided into 3 groups on the basis of the extent of increase in muscle tonus: one group with slightly increased muscle tonus (2 patients), one with moderately increased muscle tonus (6 patients), and one with markedly increased muscle tonus (2 patients).

The H-reflexes before, during, and 0, 2, 4, 6, 8, and 10 min after continuous stretching of the abductor pollicis brevis (APB) muscle of the affected side were recorded following stimulation of the median nerve at the wrist. The intensity of the constant stimulation current was 1.2 times greater than that of the minimum current required to evoke an M-wave with a stimulus frequency of 0.5 Hz and duration of 0.2 ms. Stimulation was performed 30 times in each trial. The H-reflex was analyzed for persistence, amplitude ratio of H/M, and latency, which was determined as the mean of measurable H-reflexes. Stretching comprised continuous stretching of the affected arm with shoulder joint abduction, elbow joint extension, wrist joint dorsiflexion, and finger extension for 1 min (Fig 6). Using this data, we analyzed H-reflex characteristics resulting from continuous stretching of the affected arm as well as the relationship between the effects of continuous stretching and neurological findings in the CVD patients.

Persistence and amplitude ratio of H/M were significantly lower ($p < 0.05$) after stretching than before stretching; these characteristics gradually recovered after continuous stretching. Figure 7 shows the amplitude ratio of H/M before, during, and after continuous stretching. A typical H-reflex is shown in Figure 8. There was no significant difference in latency. Persistence and amplitude ratio of H/M during continuous stretching were lower than those before and after stretching in the patients with moderately increased muscle tonus. The amplitude ratio of H/M before, during, and after continuous stretching in patients with moderately increased muscle tonus is shown in Figure 9. On the other hand, H-reflex characteristics were the same before, during, and after continuous stretching in the patients with slightly or markedly increased muscle tonus (Fig 10). Latency was the same before, during, and after continuous stretching in all patients, irrespective of slightly, moderately, or markedly increased muscle tonus.

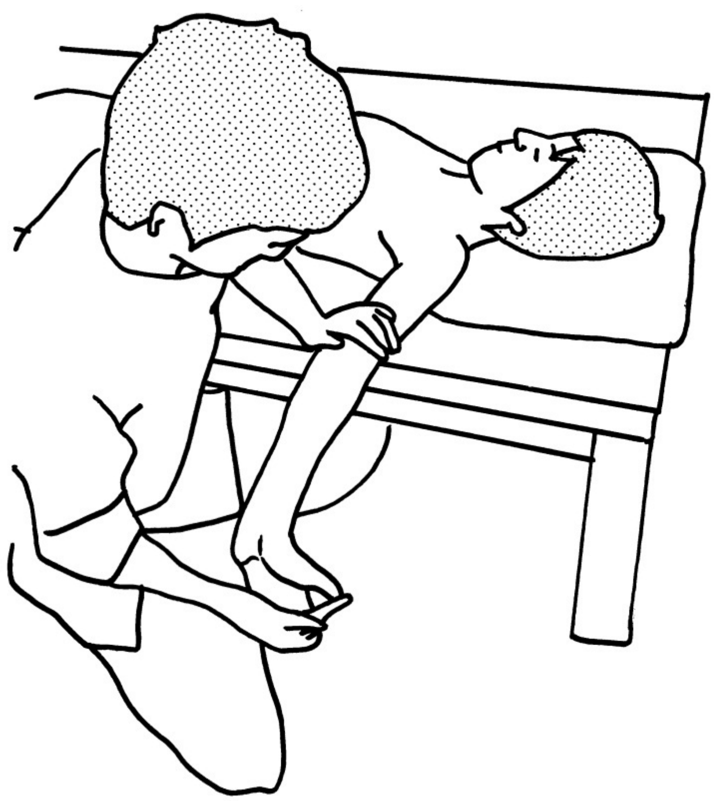


Figure 6. Continuous stretching of the affected arm with shoulder joint abduction, elbow joint extension, wrist joint dorsiflexion, and finger extension for 1 min

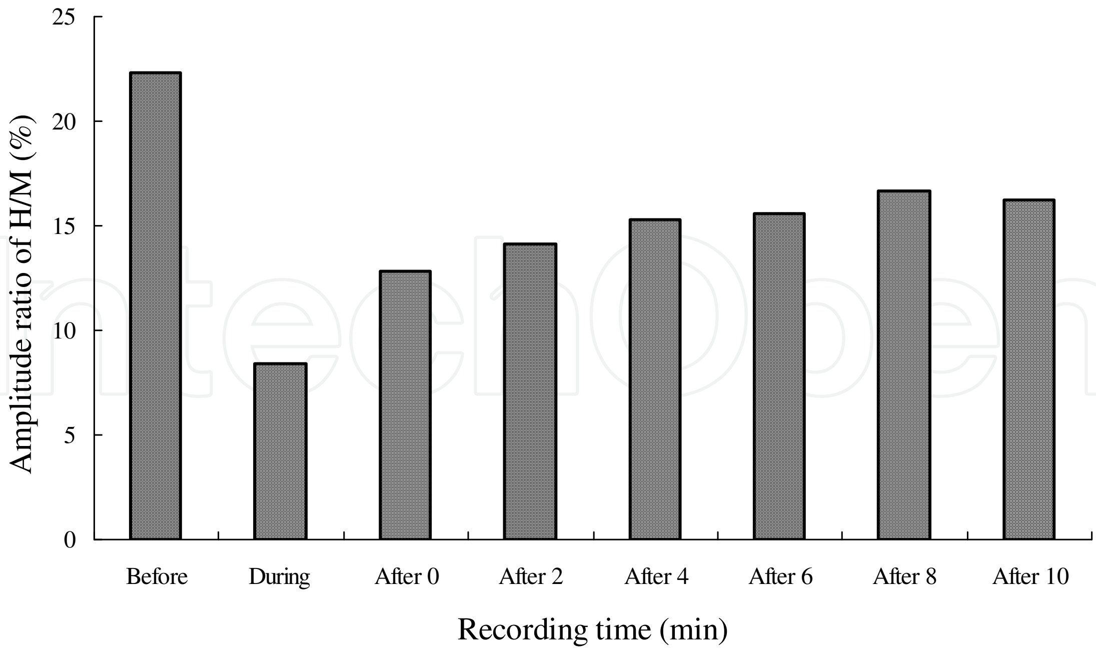


Figure 7. Characteristics of the amplitude ratio of H/M before, during, and after continuous stretching The amplitude ratio of H/M during ($p < 0.05$) and after stretching was lower than that before stretching, and it gradually increased after stretching.

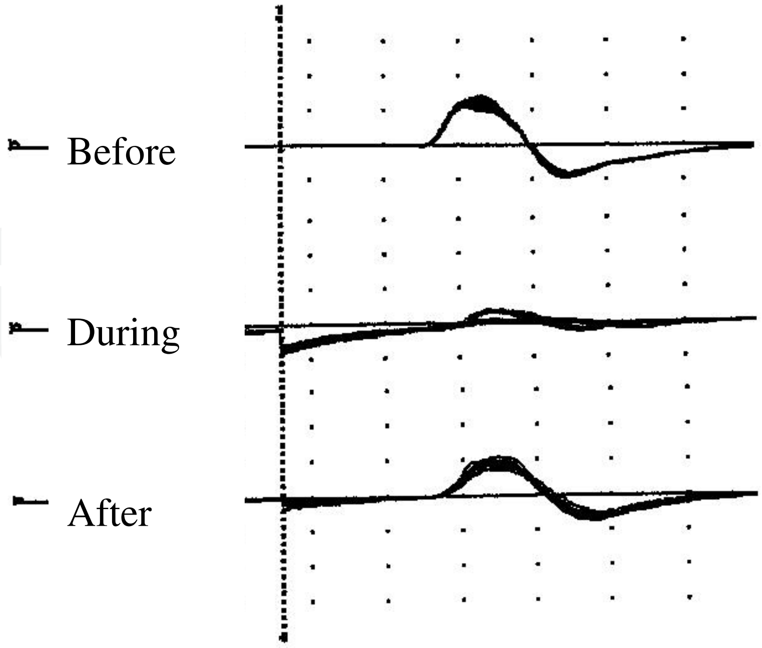


Figure 8. A typical H-reflex pattern before, during, and after continuous stretching (Left hemiplegia, 59-year-old male) The amplitude of the H-reflex during and after stretching was lower than that before stretching. The amplitude gain was 5 mV (M wave) and 1 mV (H-reflex). Gain of latency was 5 ms.

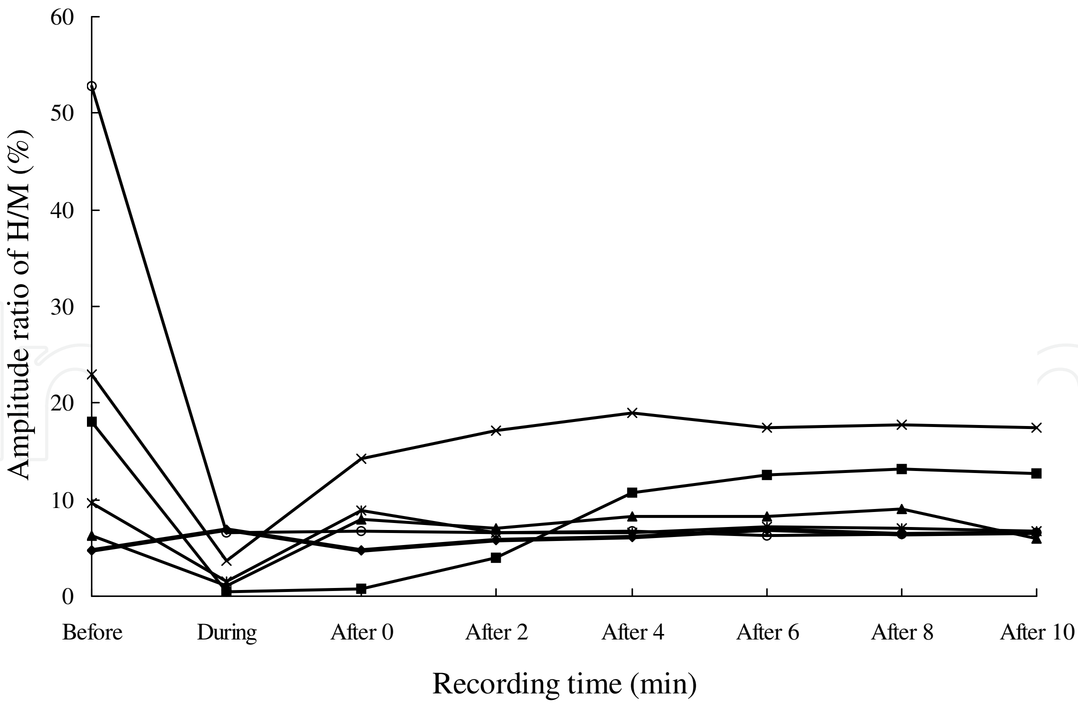


Figure 9. Characteristics of the amplitude ratio of H/M before, during, and after continuous stretching in patients with moderately increased muscle tonus The amplitude ratio of H/M during stretching was lower, while that after stretching gradually increased.

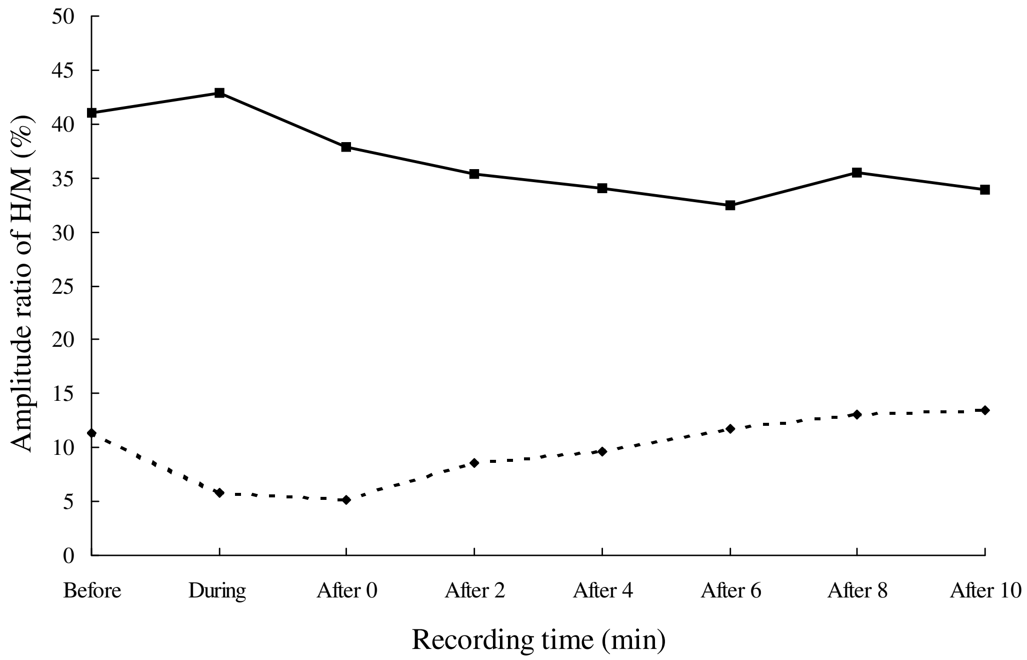


Figure 10. Characteristics of the amplitude ratio of H/M before, during, and after continuous stretching in patients with slightly and markedly increased muscle tonus The figure shows typical data in patients with slightly (dash line) and markedly (solid line) increased muscle tonus. The amplitude ratio of H/M before, during, and after stretching remained the same.

Generally, the H-reflex is suppressed during passive stretching in healthy subjects, although the mechanism has not been clarified. Depression was thought to be caused by a decrease in the number of afferent fibers fired from the Golgi tendon organs and muscle spindle during passive stretching (Paillard, 1959 and Mark et al., 1968). The increase in the H-reflex following passive stretching, caused by excitability of cortical and spinal neural function, was greater in spastic patients than in healthy subjects (Angel et al., 1963, Niesen et al., 1993, and Hashizume et al., 1985). However, our results demonstrate that H-reflexes during 1 min of continuous stretching of the affected arm were significantly decreased compared with those before continuous stretching, especially in the CVD patients with moderately increased muscle tonus. There are 3 differences between the results of other studies and our results. First is the duration of stretching, which was considerably shorter (1 min) in our study than in the other studies. It is well known that in healthy subjects, excitability of spinal neural function during continuous stretching is decreased because of the inhibitory neurons from the Ib afferents. These Ib afferents from the Golgi tendon organs, which fire in response to muscle tension, are reportedly influenced by corticospinal fibers (Lundberg et al., 1978). Excitability of spinal neural function during muscle stretching showed a greater increase in the spastic CVD patients than in the healthy subjects because Ib afferent inhibitory neurons are not fired under short stretching durations. Therefore, CVD patients require longer durations of continuous stretching of the affected hypertonic muscle to fire the Ib inhibitory neurons. The second difference lies in the stretched muscle. In the other studies, affected calf muscles were stretched, whereas in our study, the arm muscles were stretched. Therefore, differences in stretched muscle also

http://dx.doi.org/10.5772/55887

influence excitability of spinal neural function. The last difference concerns the method used. We speculate that differences in the method of muscle stretching also affect the excitability of spinal neural function. Clinically, continuous stretching of the arm involves the simultaneous stretching of several joints, particularly according to the Bobath concept. Therefore, the affected muscle tonus is changed by muscle contraction and muscle stretching in remote parts of the body.

Patients with moderately increased muscle tonus were more affected by these stretch conditions in our study. Excitability of spinal neural function during 1 min of continuous stretching was inhibited in the patients with moderately increased muscle tonus, whereas that in the patients with slightly or markedly increased muscle tonus was less affected. Therefore, it is important to examine neurological findings using continuous stretching as one of the rehabilitation treatments.

3.2. F-wave characteristics in different stretched positions of the affected arm in CVD patients

The subjects were 20 hemiparesis patients with moderate hypertonus (modified Ashworth scale score of 2 or 3) caused by CVD. Their mean age was 49.5 years. There were 10 patients with cerebral hemorrhage (5 with right and 5 with left) and 10 with cerebral infarction (5 with right and 5 with left). Computed tomography or magnetic resonance imaging confirmed the cortical lesions to be located in the temporal region in 5 patients, parietal region in 3, temporo-occipital region in 3, and brain stem in 5. The muscle tonus of the affected arm, especially the distal part, was moderately increased according to a modified Ashworth scale score of 2 or 3. The F-wave was recorded at the APB during continuous stretching for 1 min after stimulation of the median nerve at the wrist. The first trial was a relaxation trial, followed by continuous stretching of the affected arm for 1 min in the following positions: stretched position with shoulder joint abduction (trial 2, Fig 11), stretched position with shoulder joint abduction and elbow joint extension (trial 3, Fig 12), and stretched position with shoulder joint abduction, elbow joint extension, and wrist joint extension (trial 4, Fig 6). The intensity of the constant stimulation current was 1.2 times greater than that of the minimum current required to evoke a maximal M-wave with a stimulus frequency of 0.5 Hz and duration of 0.2 ms. Stimulation was performed 30 times in each trial. The F-wave was analyzed for persistence, amplitude ratio of F/M, and latency, which were the mean values of the measurable F-waves. Using this data, F-wave characteristics during continuous stretching (trials 2–4) were compared with those during relaxation (trial 1) in the CVD patients with moderately increased muscle hypertonus.

The following results were analyzed: 1) relationship between F-wave characteristics in trial 1 and trial 2, 2) relationship between F-wave characteristics in trial 1 and trial 3, and 3) relationship between F-wave characteristics in trial 1 and trial 4.

With regard to the relationship between F-wave characteristics in trial 1 and trial 2, persistence, amplitude ratio of F/M, and latency were the same in trial 1 and 2.

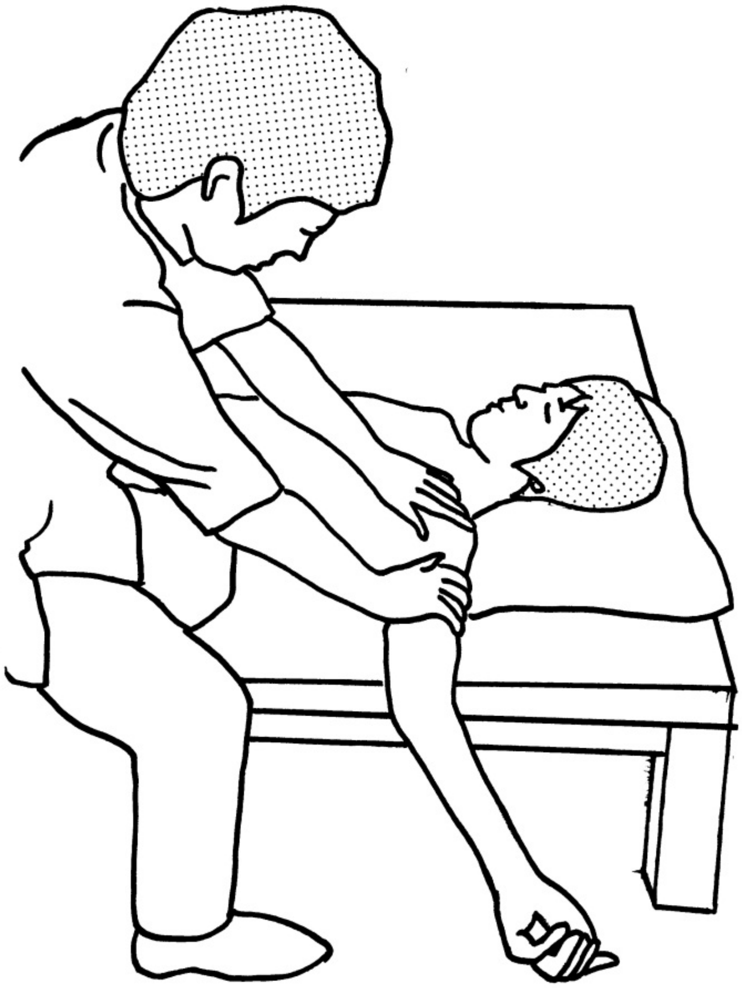


Figure 11. Continuous stretching of the affected arm with shoulder joint abduction for 1 min

http://dx.doi.org/10.5772/55887

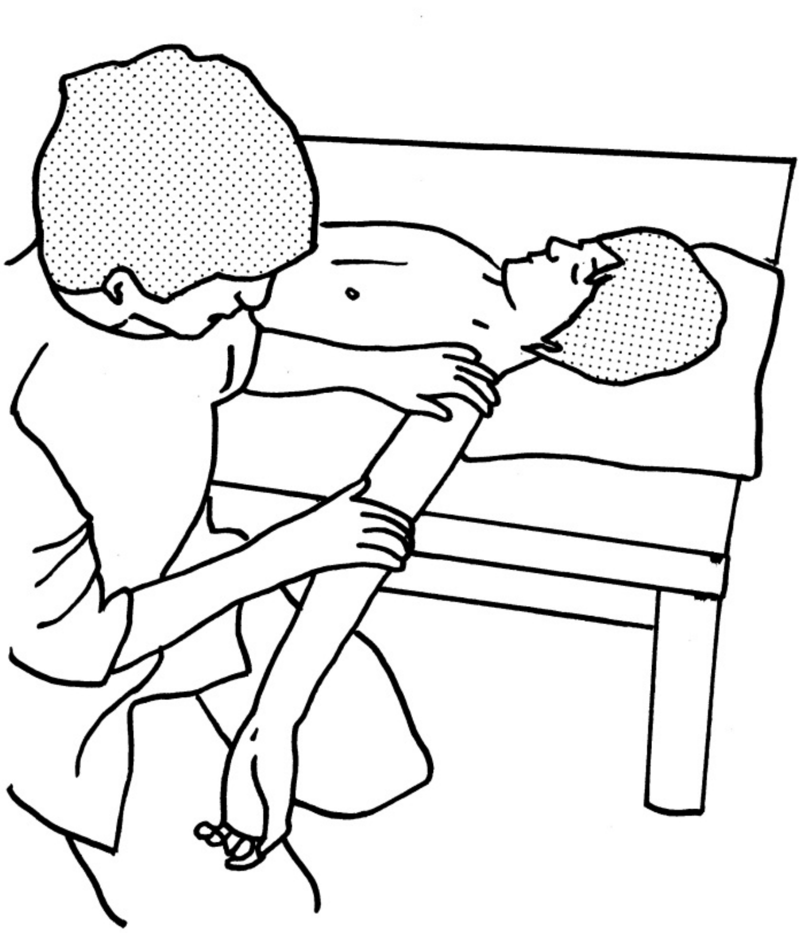


Figure 12. Continuous stretching of the affected arm with shoulder joint abduction and elbow joint extension for 1 min

With regard to the relationship between F-wave characteristics in trial 1 and trial 3, persistence and amplitude ratio of F/M were significantly lower in trial 3 than in trial 1 ($p < 0.05$; Table 3 and Fig 13). No significant difference was noticed in latency between trials 1 and 3.

	trial 1	trial 3	t-test
Persistence (%)	100 ± 0.00	91.0 ± 41.8	p < 0.05
Amplitude ratio of F/M (%)	10.8 ± 3.5	2.71 ± 3.53	p < 0.05
Latency (ms)	25.3 ± 2.28	25.6 ± 3.17	NS

NS: Not Significant

Persistence and amplitude ratio of F/M in trial 3 were significantly lower than those in trial 1.

Table 3. F-wave characteristics in trials 1 and 3

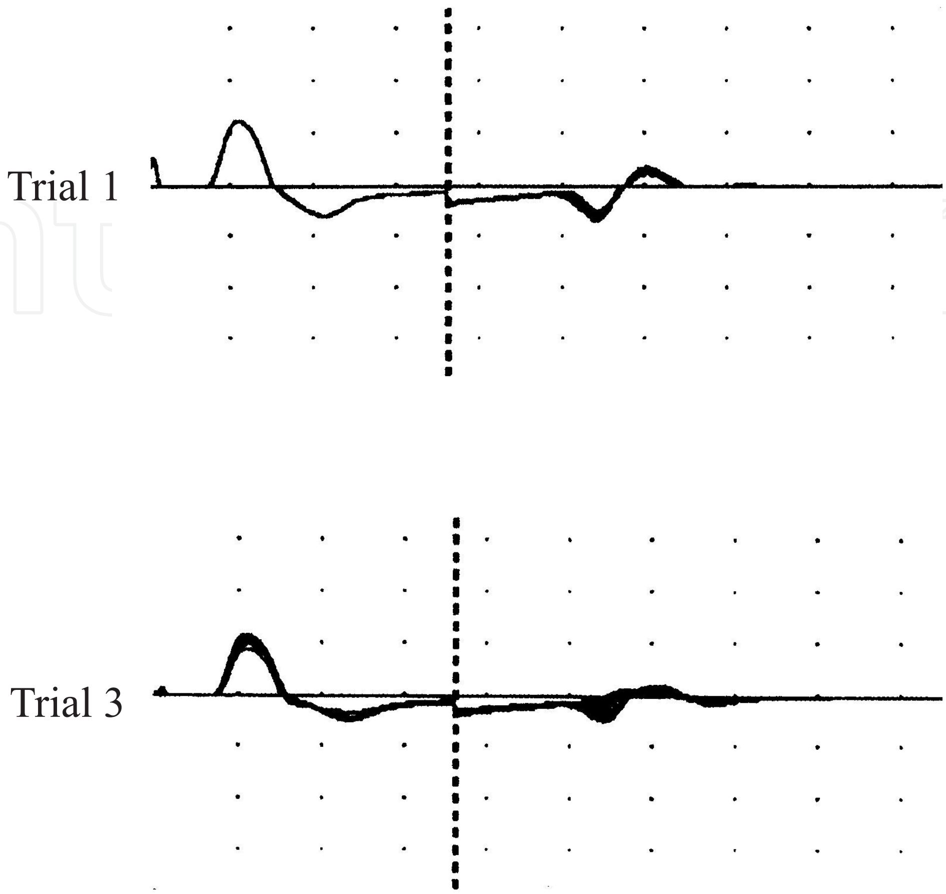


Figure 13. A typical F-wave in trial 1 and 3 Amplitude of the F-wave in trial 3 was significantly lower than that in trial 1. The amplitude gain was 5 mV/D (M-wave) and 2 mV/D (F-wave). The latency gain was 5 ms/D for both the M-wave and F-wave.

With regard to the relationship between F-wave characteristics in trial 1 and trial 4, persistence and amplitude ratio of F/M were significantly lower in trial 4 than in trial 1 ($p < 0.05$; Table 4 and Fig 14). No significant difference was noticed in latency between trials 1 and 4.

	trial 1	trial 4	t-test
Persistence (%)	100 ± 0.00	82.5 ± 21.8	p < 0.05
Amplitude ratio of F/M (%)	7.34 ± 3.5	4.26 ± 3.78	p < 0.05
Latency (ms)	24.5 ± 2.58	24.5 ± 2.58	NS

NS: Not Significant

Persistence and amplitude ratio of F/M in trial 4 were significantly lower than those in trial 1.

Table 4. F-wave characteristics in trials 1 and 4

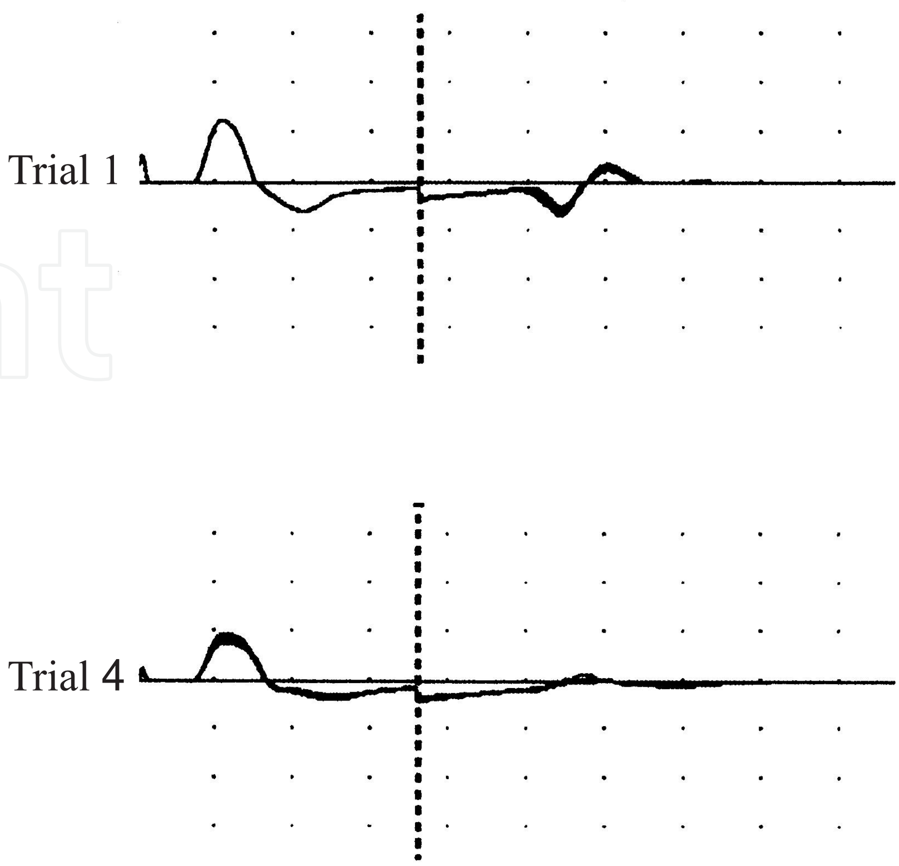


Figure 14. A typical F-wave in trials 1 and 4 The F-wave amplitude in trial 4 was significantly lower than that in trial 1. The amplitude gain was 5 mV/D (M-wave) and 2 mV/D (F-wave). The latency gain was 5 ms/D for both the M-wave and F-wave.

Furthermore, persistence and amplitude ratio of F/M of F-waves generated by the APB were significantly lower during 1 min of stretching in all positions than during relaxation (no stretched position) in the CVD patients with moderate hypertonus. All stretching positions decreased the excitability of spinal neural function.

The method of stretching the affected arm involved the simultaneous stretching of several muscles rather than just one muscle. The period of continuous stretching in our study was shorter (1 min) than that in the other studies (10 min, 30 min; Odeen, 1981).

Continuous stretching of the proximal shoulder and elbow of the affected arm is believed to decrease excitability of spinal neural function due to Ib inhibitory neuron afferents (Mark et al., 1968) and central nervous function (Staines WR et al., 1997). We hypothesize that decreasing excitability of proximal spinal and central neural function can decrease excitability of distal spinal neural function in patients with hemiparesis accompanied by moderate hypertonus caused by CVD.

Our study suggests that excitability of distal spinal neural function in the APB of the affected arm decreases during continuous stretching of the proximal muscle and shoulder and elbow joints or all the shoulder, elbow, and wrist joints.

4. Conclusions

Summary of this study report

1. We examined H-reflex and F-wave data resulting from increased stimulus intensity in the affected arm in patients with CVD. The results suggested that the characteristic appearance of the H-reflex and F-wave resulting from increased stimulus intensity reflects the neurological findings of CVD and can be used to evaluate excitability of spinal neural function in patients with CVD.

2. To investigate excitability of spinal neural function during stretching in CVD patients, H-reflex data was obtained before, during, and after 1 min of continuous stretching of the APB of the affected arm after stimulation of the median nerve. Persistence, amplitude, and amplitude ratio of H/M were lower during stretching than before and after stretching in the patients with moderately increased muscle tonus, whereas these characteristics were the same before, during, and after continuous stretching in the patients with slightly and markedly increased muscle tonus. These results suggested that excitability of spinal neural function during 1 min of continuous stretching of the affected arm was inhibited in CVD patients with moderately increased muscle tonus.

3. F-wave data was obtained from the APB during relaxation (trial 1) and continuous stretching of the affected arm for 1 min in different positions in patients with CVD: stretched position with shoulder abduction (trial 2), stretched position with shoulder abduction and elbow extension (trial 3), and stretched position with shoulder abduction, elbow extension, and wrist extension (trial 4). Persistence and amplitude ratio of F/M were the same in trial 2 and trial 1 and significantly lower in trials 3 and 4 than in trial 1. These results suggested that excitability of spinal neural function in the APB of the affected arm was decreased during continuous stretching of the proximal muscle and shoulder and elbow joints or all the shoulder, elbow, and wrist joints in patients with hemiparesis accompanied by moderate hypertonus caused by CVD.

Acknowledgements

We would like to thank Mr. Onuma T. for his assistance in this study.

Author details

Toshiaki Suzuki[1], Tetsuji Fujiwara[2], Makiko Tani[1] and Eiichi Saitoh[3]

1 Graduate School of Kansai University of Health Sciences, Japan

2 Kyoto University, Japan

3 Fujita Health University, Japan

References

[1] Angel RW & Hofmann WW (1963). The H-reflex in normal, spastic, and rigid subjects. *Archives of Neurology*, Jun 1963), 0003-9942, 9, 591-596.

[2] Eisen A & Odusote K (1979). Amplitude of the F-wave: A potential means of documenting spasticity. *Neurology*, Sep 1979), 0028-3878, 29, 1306-1309.

[3] Fisher MA (1983). F response analysis of motor disorders of central origin. *J. Neurolo. Sci.*, Dec 1983), 0002-2510X, 62(1-3), 13-22.

[4] Hashizume M, Koike Y, Hayashi F, Sakurai N, & Sobue I (1985). The inhibition of H-reflexes by passive static and sinusoidal stretch in normal subjects and spastic patients (In Japanese). *Clinical Neurology*, Aug 1985), 0000-9918X, 25(8), 911-919.

[5] Kimura J (1974). F-wave velocity in the central segment of the median and ulnar nerves. A study in normal subjects and in patients with Charcot-Marie-Tooth disease. *Neurology*, Jun 1974), 0028-3878, 24(6), 539-546.

[6] Lundberg A, Malmgren K, & Schomburg ED (1978). Role of joint afferents in motor control exemplified by effects on reflex pathways from Ib afferents. *Journal of Physiology*, Nov 1978), 0022-3751, 284, 327-343.

[7] Mark RF, Coquery JM, & Paillard J (1968). Autogenetic reflex effects of slow or steady stretch of the calf muscles in man. *Experimental Brain Research*, 0014-4819, 6(2), 130-145.

[8] Nielsen J, Petersen N, Ballegaard M, Biering-Sørensen F, & Kiehn O (1993). H-reflexes are less depressed following muscle stretch in spastic spinal cord injured patients than in healthy subjects. *Experimental Brain Research*, 0014-4819, 97(1), 173-176.

[9] Odéen I & Knutsson E (1981). Evaluation of the effects of muscle stretch and weight load in patients with spastic paraplegia. *Scand J Rehabili Med*, 0036-5505, 13(4), 117-121.

[10] Odusote K & Eisen A (1979). An electrophysiological quantitation of the cubital tunnel syndrome. *The Canadian Journal of Neurological Sciences*, Nov 1979), 0317-1671, 6(4), 403-410.

[11] Paillard J (1959). Functional organization of afferent innervation of muscle studied in man by monosynaptic testing. *American Journal of Physical Medicine*, Dec 1959), 0002-9491, 38, 239-247.

[12] Staines WR, Brook JD, Cheng J, Misiaszek JE, & MacKay WA (1997). Movement-induced gain modulation of somatosensory potentials and soleus H-reflexes evoked from the leg. I. Kinaesthetic task demands. *Exp Brain Res*, (Jun 1997), Jun 1997), 0014-4819, 115(1), 147-155.

[13] Suzuki T, Fujiwara T, & Takeda I (1993). Excitability of the spinal motor neuron pool and F-wave during isometric ipsilateral and contralateral contraction. *Physiotherapy Theory and Practice*, 0959-3985, 9, 19-24.

[14] Suzuki T, Fujiwara T, & Takeda I (1993). Characteristics of F-wave during relaxation in patients with CVD (In Japanese). PT journal, 0915-0552, 27, 277-281.

IntechOpen