Spinal Reflex Excitability Changes After Lumbar Spine Passive Flexion Mobilization

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Abstract

Background: Flexion distraction has gained increased credibility as a therapeutic modality for treatment of low back pain. Although important work in the area has elucidated the intradiskal pressure profiles during flexion distraction, the accompanying neural responses have yet to be described.

Objective: The purpose of this pilot study was to assess neural reflex responses to motion with 3 degrees of freedom applied to the lumbar spine and to evaluate H-reflex responses of the soleus.

Methods: Subjects (n = 12) were measured for H-maximum reflexes determined from stimulus response recruitment curves measured in neutral prone position. The mean of 10 evoked H-waves (at H-maximum stimulus intensity) were measured in neutral position, flexion, left and right lateral flexion, and axial rotation of the trunk on an adjusting table. H-reflexes were expressed as a percentage of maximal M-wave for the criterion measure. Spinal range of motion was quantified by digitization.

Results: The data showed variation in some movement ranges, notwithstanding identical table positioning for all subjects. Mean H-reflex amplitude was decreased (15.2 ± 5.8 mV to 13.8 ± 5.8 mV), and the H/M ratio was also decreased in flexion compared with neutral (55.0% ± 19.1% to 50.3% ± 19.4%; $P < .05$).

Conclusions: Trunk flexion is accompanied by inhibition of the motor neuron pool. Slight perturbations in numerous afferent receptors are known to significantly alter the H-reflex. The absence of measurable changes in lateral flexion and trunk rotation may indicate that both slow- and fast-adapting receptors could be involved in lumbar motion. These preliminary findings suggest the need for further dynamic motion studies of the flexion distraction neurophysiologic condition. (J Manipulative Physiol Ther 2002; 25:526-32)

Key Indexing Terms: *H-Reflex; Motorneuron; Neurophysiology; Low Back Pain; Chiropractic*

Introduction

Spinal manipulative therapy (SMT) has been theorized to relieve low back pain (LBP) by several mechanisms. One recently reported mechanism is thought to reduce pain because of a reduction in mechanical nerve compression of the dorsal and ventral rami caused by SMT.[1] The possible mechanisms implicated for the hypoalgesic effect of SMT have included activation of a central control mechanism,[2] activation of zygapophyseal joint capsule stretch reflex-mediated inhibition,[3] and afferent discharges from cutaneous receptors, muscle spindles, mechanoreceptors, and free nerve endings in the annulus fibrosus and ligaments of the spine.[4,5] These findings suggest a neurophysiologic basis for the therapeutic action of SMT in patients with LBP. The exact mechanisms for LBP symptom reduction caused by SMT is still unknown despite significant strides toward better understanding the treatment of LBP. A series of clinical observations have detailed additional possible mechanisms related to positive outcomes for treatment of LBP in one case study in which a patient has significant pain reduction where discal bulging was reduced by 14%.[6] In a follow-up study, the same investigators reported reduced L5-S1 disk protrusion after spinal flexion-distraction (FD) therapy, which was demonstrated by repeated computed tomography scanning.[7] A

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recent investigation using unembalmed cadavers documents reduced intradiskal pressure in lumbosacral flexion during a FD procedure.[8] In addition to the reduction of obstructive or compressive lesions, various spinal and paraspinal receptors may be activated during spinal FD. These receptors are contained in zygapophyseal joint capsule, muscle spindles, intervertebral disks, and spinal ligaments. All of these mechanoreceptors may potentially contribute to the neurophysiologic responses associated with spinal manipulation and mobilization procedures.

A recent report indicates that spinal ligaments offer a significant contribution to reflex excitability when studied in a static and dynamic spinal force model in the feline lumbar spine.[9] Supraspinal ligament stimulation at the L6 level inhibited reflexes during flexion.[9] A similar reflex inhibition is reported to occur as a result of cervical flexion.[10] Spinal flexion may be an important reflex inhibitor and potential mediator of reduced LBP, perhaps by relaxing the paraspinal musculature.[11] In addition, the FD technique appears to exert a mechanical influence on intradiskal pressure.[8] The reduction in intradiscal pressure and subsequent reduction in neural encroachment of herniated intervertebral disk material (HNP) is the mechanical foundation of the technique. The mechanical compression model, along with reduction in HNP, does not solely explain the changes in motor unit activation and reduction of paraspinal spasm as proposed by advocates of this technique (neural mechanism). Recently, we have reported profound attenuation of spinal reflex responses to high-velocity, low-amplitude SMT and nonthrust spinal mobilization techniques in healthy adults.[12] Because the FD procedure is a highly popular, conservative mobilization (nonthrust) treatment procedure for LBP, this study describes the effect of the flexion movement component in lumbar spine FD mobilization in normal adults during varying static planar movements commonly used during the FD procedure.

Methods

Subjects

A total of 7 male and 5 female normal, healthy subjects (N = 12) without known neurologic disease or low back pain were recruited from the student body and staff of a local college. Subjects were given a detailed description of the study and gave informed consent before participation, as required by the Institutional Review Board. Descriptive data for the subjects are provided in Table 1.

Table 1. *Descriptive data for normal symptom-free male (n = 7) and female (n = 5) subjects (N = 12)*

Age (y)	Height (in)	Weight (lb)	Sex
23	68	175	M
23	72	170	M
30	70	158	M
22	68	156	F
29	67	163	M
24	67	150	F
26	61	120	F
34	64	135	F
34	60	185	F
40	70	196	M
29	72	167	M
37	69	182	M
Mean ± SD			
29. 3 ± 6.2	67.4 ± 4.0	163.1 ± 22.4	

Procedures

Subjects rested prone on a FD table (Zenith-Cox Model 95, Elgin, Ill). Maximal evoked muscle action potentials (M-waves) and maximal electrically stimulated reflex potentials (H-reflex) were recorded from the triceps surae muscle of the right leg with bipolar surface electromyographic (EMG) techniques. The Braddom and Johnson bipolar electrode configuration (10-mm Ag-AgCl pregelled disposable) was used to ensure the consistency of electrode placement across subjects with the ground electrode placed over the gastrocnemius muscle, along the mid-line of the right leg to minimize stimulus artifactual noise.[13] EMG signals were amplified (gain ×100 to ×1000) and band-pass-filtered with a 10 Hz to 10 kHz bandwidth (Grass P511 EMG Amplifier, Grass Instruments, West Warwick, RI). Maximum M-waves and maximum H-reflexes were evoked by stimulating (Grass S-88 Stimulator, Grass Instruments, West Warwick, RI) the tibial nerve in the popliteal fossa with a 1-millisecond transcutaneous pulse in accordance with the H- and M-max recruitment curve method outlined by Hugon.[14] These responses were evoked at a rate of 0.1 Hz.

After recording baseline M-waves and H-reflexes in a prone neutral position, the trunk was sequentially moved with the FD table into the following positions: (1) trunk flexion; (2) right lateral bending; (3) left lateral bending; (4) right axial rotation; and (5) left axial rotation. The trunk positioning represented the full range of motion of the FD table in the respective planes. The positioning levers on the FD table were marked to ensure consistency in repeated table excursions and positioning. Therefore, although the table was set in the same position for all subjects during a given prescribed movement, because subject positioning on the table varied and because of differences between individual subjects, subject motion in the 3 measured planes varied. The table and subject ranges of movement were documented by digitization of the subject in each of the trunk positions with a clinical digitizing device and proprietary software (Metrocom, Faro Technologies, Lake Mary, Fla). Although the clinical precision of the Metrocom has been questioned,[15] the good test/re-test reliability (r = 0.71 to 0.83) and small mean Cobb-angle difference (3.7 degrees) reported by Mior et al[15] were considered adequate for the purpose of this study, in which subject and table position

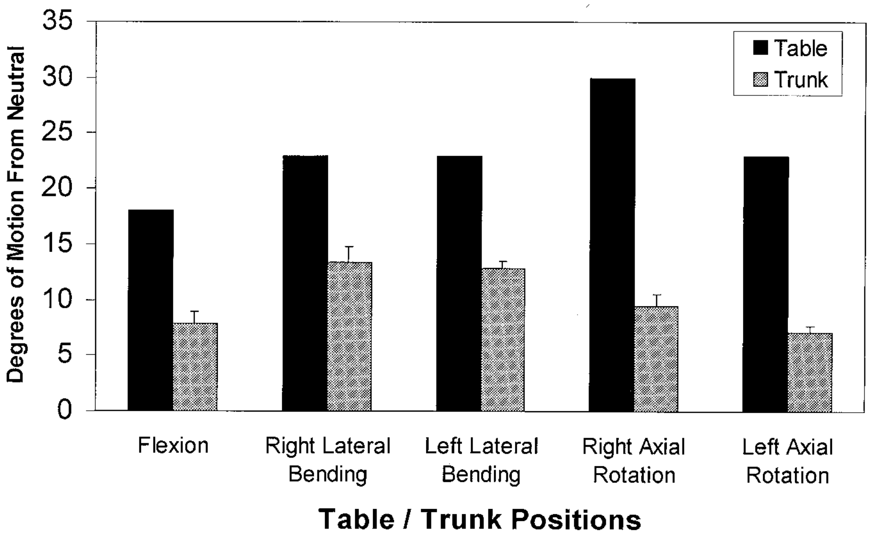

Fig 1. *Table and trunk motion during flexion-distraction positioning in 12 subjects. The table position is invariable and precisely reproduced from markings on the mechanical levers of the treatment (Zenith-Cox, Elgin, Ill) table. Subject trunk and table positions recorded from a (Metrocom) clinical digitizer (mean ± SD).*

not range of motion were the measurement objective (Fig 1).

Immediately after securing the subject into one of 6 trunk positions, including prone-neutral, 10 H-reflexes were evoked and recorded at H-max stimulus intensity. M-waves were recorded at the completion of each experimental session. For both M-wave and H-reflex responses, peak-to-peak EMG amplitudes were measured with a digital oscilloscope (Tektonix TDS 420, Beaverton, Ore). H-reflex amplitudes represented an average of 10 responses, whereas the M-wave amplitudes represented an average of 3 responses, as recommended by Hugon.[14] We have previously reported details of the H–reflex technique.[12]

Statistical Procedures

A 1-factor repeated-measures analysis of variance model was used to show the effect of various trunk positions on H-reflex amplitude. H-reflex amplitudes were normalized to maximal M-wave amplitudes and expressed as an H/M ratio. The H/M ratio is an index of alpha motoneuron pool excitability. $P < .05$ was considered statistically significant.

Results

The therapy table motion for each of the 5 nonneutral positions was reproducible and did not vary among subjects. Subject trunk position (motion) showed minor variations among subjects and is compared with the accompanying table motion for each table and trunk position combination in Figure 1. Maximum M-wave amplitudes recorded at the beginning and end of the experiment were similar (Fig 2). Maximum H-reflex amplitudes recorded throughout the experimental session in the prone neutral position post-flexion, post-lateral flexion, and post-axial rotation were also similar (Fig 3). Submaximal M-wave responses recorded with each maximum H-reflex response in the neutral and experimental trunk positions were constant (Fig 4). These data indicate that the EMG recording environment was stable, the order of testing did not bias the result, and the stimulus parameters were constant.

There were significant decreases in the H-reflex amplitude (15.2 ± 5.80 mV to 13.8 ± 5.81 mV; $P < .05$) and the H/M percentage ratio (55.0% ± 19.12% to 50.3% ± 19.38%; $P < .05$) when the trunk was positioned in flexion compared with neutral (Figs 4 and 5). These differences represent a 9% decrease in alpha motoneuron pool excitability. The decrease in alpha motoneuron pool excitability with trunk flexion is evident when H/M percentage ratios were expressed as a percent change from the neutral position for each subject (Fig 6).

Discussion

The findings of this preliminary investigation combined with previous reports strengthen the theory that FD therapy mechanisms may be both mechanical and neurophysiological. The discussion reviews these findings in light of the current data.

Low back pain is one of the leading causes of work-related disability in the industrial world.[16] Pharmacologic and surgical approaches for treating LBP have met with limited success; recent medical and economic reports in a managed health care environment have made the search and need for cost-effective and alternative conservative treatments desirable.[16-18] Although traditional spinal manipulative procedures are well-established for effective treatment

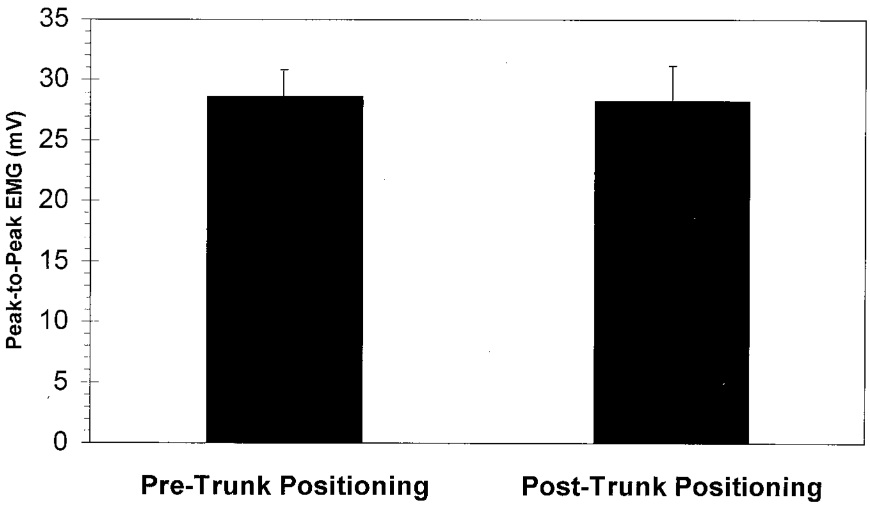

Fig 2. *Maximal gastrocnemius M-wave recordings before and after trunk positioning. M-waves were not significantly different (mean ± SD).*

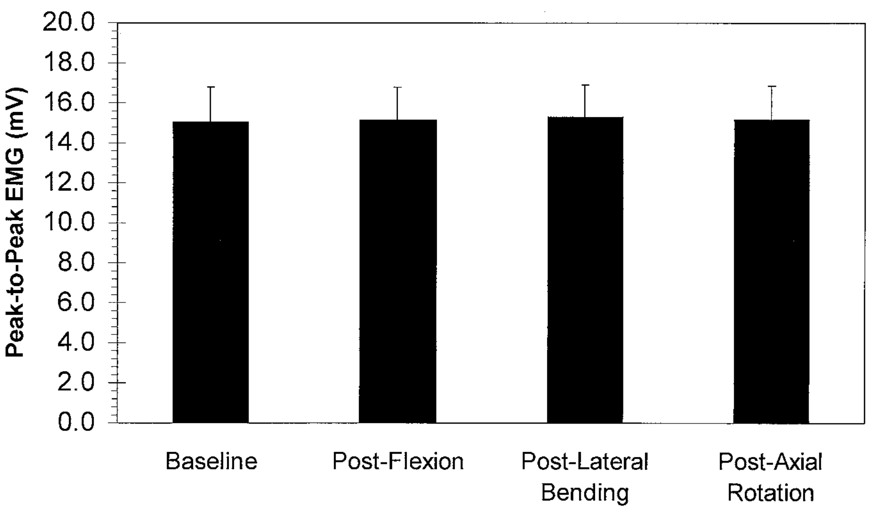

Fig 3. *Gastrocnemius H-reflex recordings after return to neutral premobilization position for all tested planar motions (see Fig 4 for details). H-reflexes did not show variation from baseline (mean ± SD).*

of specific types of LBP and other acute or chronic musculoskeletal disorders,[19,20] the need exists for conservative management of LBP and radiculopathy resulting from HNP, where high-velocity and low-amplitude procedures may be relatively contraindicated.[21-23]

Experimental Neurophysiology Research Evidence

The results of this research show that the flexion component performed during a FD low-velocity mobilization procedure used in the conservative management of LBP inhibits lumbar spinal reflex excitability. This inhibition is presumed to play an important role in the management of LBP associated with hypertonicity and activation of erector spinae muscles.[11,24,25] This finding suggests that cutaneous receptors, muscle spindles, and Golgi tendon organs rather than velocity-dependent joint mechanoreceptors may contribute to most afferent discharge inhibitory interneuron pools during low-velocity lumbar FD mobilization procedures.[4,5] These data are supported by the findings of Dishman and Bulbulian,[12] who report spinal motor neuron pool inhibition with lumbosacral high-velocity, low-amplitude SMT and spinal mobilization without high velocity. In addition, Herzog et al[26] have also reported that paraspinal muscle reflex activation does not differ from spinal manipulation procedures accompanied by an audible release from a joint compared with manipulations not accompanied by an audible release. Presumably, treatments not accompanied by an audible release represent spinal manipulations that do not overextend the joint through the full end range of passive motion into the so-called paraphysiologic range. Recent

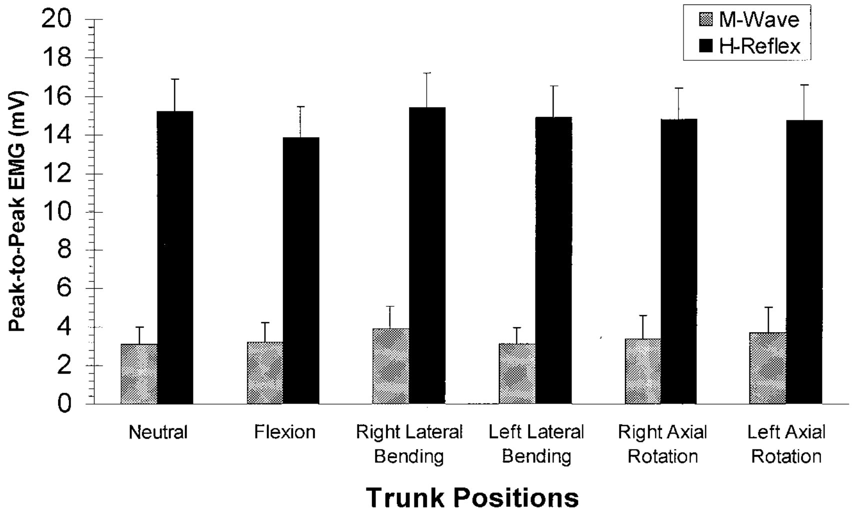

Fig 4. *Gastrocnemius M-waves and H-waves in neutral prone, flexion, left and right lateral flexion, left and right axial rotation. Reflex measures represent the average of 10 repeated, mechanical (table) end-range spinal positions in 12 asymptomatic normal subjects (mean ± SD).*

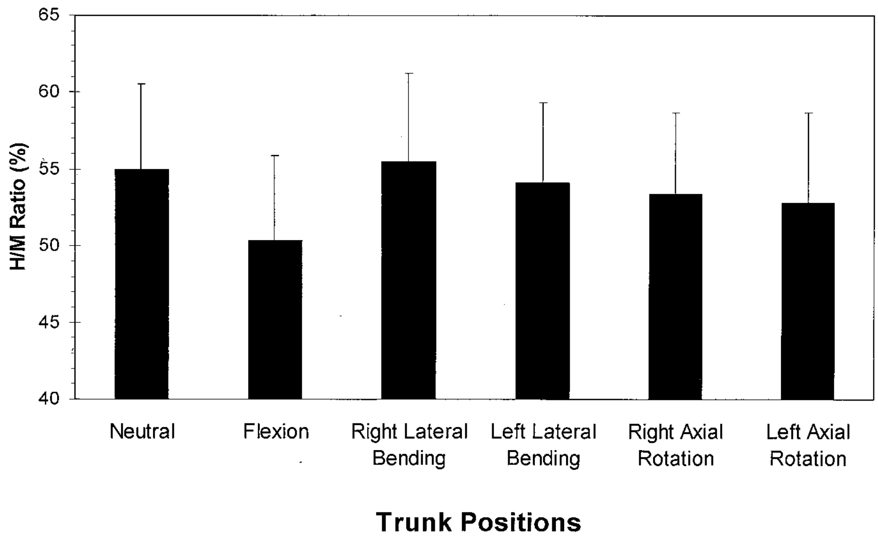

Fig 5. *Gastrocnemius H/M ratio during neutral and flexion-distraction-type flexion and rotation movements (see Fig 4 for experimental details). The flexion data are significantly different than all other H/M ratio data ($P < .05$; mean ± SD).*

investigations in the neural components of LBP and radiculopathy have suggested numerous tissues as possible nociceptive generators in patients with LBP. Internal disk derangement without frank HNP may also play a role in the generation of LBP. In addition to mechanical neural encroachment and joint capsule or muscle receptor inputs, ligamentous afferent is involved in spinal reflexes as shown in the feline lumbar spine. Supraspinal ligament stimulation at the L6 level inhibits reflexes during flexion.[9] Sabbahi and Abdulwahab[10] have demonstrated a 10% to 51% facilitation in the flexor carpi radialis motoneuron pool accompanying most head movement positions except flexion, which exhibited an 8% motorneuron pool inhibition.

As in this study, it is not fully understood why flexion appears to be the most responsive to the criteria outcome measures in these experimental studies. We theorize, however, that spinal flexion leads to motoneuron inhibition as a mechanism of reducing antagonistic action on the extensor muscles. This is evident in reports elucidating the so-called flexion-relaxation response.[11] In this response, the lumbar erector spinae are known to eccentrically contract during standing volitional lumbar flexion; however, when the end range of flexion is achieved, there is a period of electromyographic quiescence.[11] It is postulated that this phenomenon is generated by mechanical stress-induced stimulation of mechanoreceptors contained in the supporting spinal and

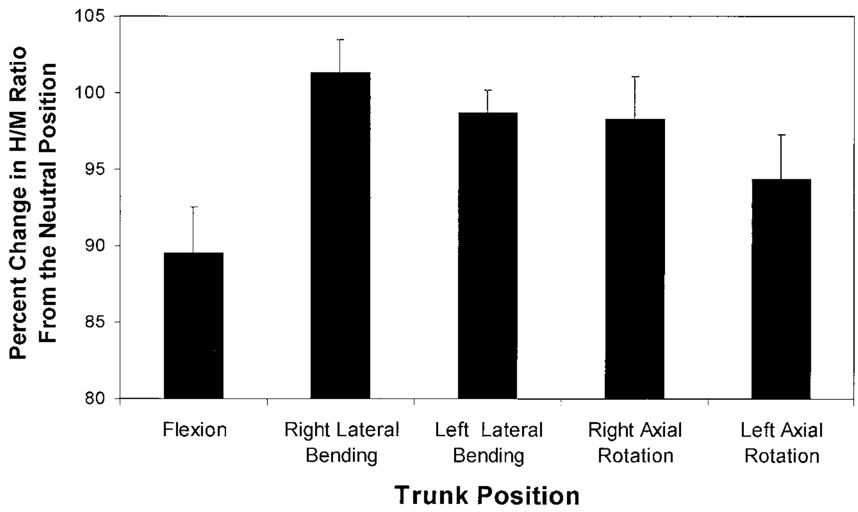

Fig 6. *Gastrocnemius H/M ratio changes expressed as a percent change from neutral position. Flexion motion for the trunk is significantly different from all other positions ($P < .05$). See Fig 4 for experimental details.*

paraspinal structures.[11] These mechanoreceptor-containing structures include the intervertebral disks, paraspinal ligaments, zygapophyseal joint capsules, and paraspinal muscles. A careful review of the current data showed only 4 of 12 subjects with inhibited H-reflexes during right axial rotation and the same for left axial rotation. Only in 2 cases was bilateral inhibition observed. In total, to the extent that a component of LBP is related to paraspinal muscle activation,[24] these reports suggest that cutaneous receptors, muscle spindles, and Golgi tendon organs that contribute to mediation of spinal reflex inhibition are not force- and velocity-dependent.

Clinical Research Evidence

In support of the experimental laboratory research, a separate series of clinical observations have detailed additional possible mechanisms related to the positive outcomes observed in conservative treatment of discogenic LBP. Cox and Aspegren[6] reported a case study where the patient had significant pain reduction, with discal bulging reduced by 14% after FD treatment. In a follow-up study, they reported reduced L5-S1 disk protrusion after spinal FD procedures, as seen on repeated computed tomography scanning.[7] A recent investigation using cadavers reported reduced intradiscal pressure in lumbosacral flexion during a FD procedure.[8] It appears that the experimental, clinical, and current research literature has created a foundation and provided documentation for proposed mechanisms of action for low-velocity manipulative treatment therapies in the management of acute or chronic LBP.

Conclusion

The FD procedure is one of the most widely used techniques in the chiropractic profession. The FD procedure is commonly used as an effective and conservative low-velocity treatment technique in the management of LBP, especially in cases arising from intervertebral disk derangement. The purpose of this study was to describe the spinal reflex responses after lumbosacral spine mobilization during static planar movements associated with the flexion motion, which was performed as a part of the FD procedure in healthy adults. The data are in agreement with the flexion-relaxation reflex response theories and also add support to the 8% H-reflex amplitude reduction as a consequence of cervical flexion, which was reported by Sabbahi and Abdulwahab[10]. In contrast, however, these data were recorded in the static mode, and dynamic reflex responses at the end of the range of motion may yield different results. Experiments involving spinal reflex assessment during dynamic FD are currently in progress in our laboratory.

In conclusion, these data clearly demonstrate that the response of the spinal reflex to FD is one of significant attenuation. Thus, the findings of this preliminary investigation combined with previous reports of the biomechanic effects support the theory that FD therapy mechanisms may be both mechanical and neurophysiologic. These preliminary data lay the foundation for further scientific inquiry of the neurophysiologic mechanisms involved in this frequently used therapeutic procedure.

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