ORIGINAL ARTICLE

H-Reflex Attenuation After Lumbosacral Manipulation in Patients With Low Back Pain

Mohaddeseh Azadvari[1], Seyede Zahra Emami Razavi[1], Farid Rezaiee-Moghaddam[2], Zahra Reza-Soltani[2], Sirus Azizi[2], Amir Rakhshan[3]

[1] *Department of Physical Medicine and Rehabilitation, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran*
[2] *Department of Physical Medicine and Rehabilitation, Emam Reza Hospital, Aja University of Medical Sciences, Tehran, Iran*
[3] *Department of Foreign Languages, Tehran University of Medical Sciences, Tehran, Iran*

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Abstract- Spinal manipulation is a manual technique commonly used for the treatment of low back pain. The physiologic mechanisms of the spinal manipulation are largely unknown. One basic physiologic response for spinal manipulation is an alteration in motoneuronal activity, as assessed by the Hoffmann reflex (H-reflex) technique. The purpose of this study was to determine the effect of spinal manipulation on the amplitude and onset latency of H-reflex and on H/M amplitude ratio in patients with low back pain. Fifty-Eight patients with low back pain aged between 20-60 years, who had no exclusion criteria were included. Tibial nerve H-reflex and M wave were recorded before and after Lumbosacral spinal manipulation. Lumbosacral manipulation significantly decreased the amplitude of the H-reflex and H/M amplitude ratio (P<0.05). It had no significant effect on H-reflex latency or M wave amplitude and latency (P>0.05). Lumbosacral manipulation produces attenuation of alpha motoneuronal excitability. These findings support this theory that manual spinal therapy can lead to a reduction in muscle tone.
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Introduction

Low back pain (LBP) is the fifth most expensive health condition in the United States (1) and is considered to be of the most prevalent for seeking medical care and accounts for over 3.7 million physician visits per year in the United States. Ninety percent of adults will experience LBP in their lifetime, 50% will experience recurrent back pain, and 10% will develop chronic pain and related disability (2-5). LBP imposes an important economic cost on society as in the United States has been estimated at 83 million loss of workdays and $12 billion annually (1).

The prevalence of LBP in the general population of Iran according to the different age groups varies from 14.4-84.1%. LBP is the third leading cause of Disability Adjusted Life Years (DALYs) in Iranian people aged 15 to 69 years. High levels of anxiety and depression among patients with low back pain and the etiological role of job strain in causing LBP in workers has been reported in Iran (6).

Epidemiologic studies have shown that factors causing the spinal pain are increasing significantly; therefore, the incidence of spinal and low back pain is increasing (7,8). There are several therapies for LBP including manipulation. One of these common therapies, regarded as a non-operative treatment modality, among patients with pelvic pain, neck and low back tends to be spinal manipulation (9,10). Manipulation is defined as a passive movement that tends to move the components of a joint or group of joints beyond their usual physiologic range and involves high velocity and low amplitude thrust (11). An indispensable feature of manipulation is necessarily a thrust, which is an impulsion administered in a brief, sudden and careful manner. This is usually preceded by a number of normal and passive movements. Manipulation is distinguished by a defining factor, i.e., dynamic thrust, from other types of manual therapy. There exist two forms of the thrusting technique, low and high velocity. A controlled force applied with high velocity along with low amplitude, which is exerted in a particular direction, and at a regulated size and depth is

Corresponding Author: S.Z. Emami Razavi
Department of Physical Medicine and Rehabilitation, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 21 61192291 , Fax: +98 21 66581516, E-mail address: zemamirazavi@gmail.com

considered as the most common feature of the adjustive dynamic thrust. During spinal manipulation, the practitioner applies a dynamic thrust on the special regions (12).

Therapeutic effects of spinal manipulation include stretching of periarticular soft tissue, improvement of range of motion and decreasing of prearticular edema (13-16). Besides, other effects of spinal manipulation include decreasing muscle spasm and pain (17).

The exact mechanism underlying the neurophysiologic effects of spinal manipulation has yet to be determined. With regard to the mechanical aspects, the manipulation of the spine is assumed to cause the relief of the mechanical compression of nerves at ventral and dorsal rami (18).

Results of recent investigations suggest that spinal manipulation may produce hypoalgesia by activation of a central control mechanism (19). Other investigators have postulated that spinal manipulation may produce a stretch reflex from joint capsules that may lead to inhibition of muscle spasm. A recently proposed mechanism for the attenuation of pain after spinal manipulation is that the procedure elicits an inhibitory stretch reflex response generated from the capsules of the zygapophysial joints (20).

In support of this neurophysiological mechanism, Indahl *et al*., using a porcine model, reported that distension of the zygapophysial joint by injection of physiologic saline reduced the amplitudes of motor unit action potentials recorded from the paraspinal musculature. In particular, mechanical perturbation including spinal manipulation has the potential to start various discharges from cutaneous receptors, mechanoreceptors, muscle spindles as well as free nerve endings in the zygapophysial joint capsule along with the ligaments of the spine (20,21). These afferent discharges may synapse on inhibitory interneurons to inhibit alpha motor neuron pools of the paraspinal musculature (20). However, other researchers state that the spinal manipulation may give rise to excitatory effects on the motor neuron pool. Therefore, there exists a paradox in researching the mechanism via which spinal manipulation may exert on the excitability of the motor neuron pool. This apparent paradox is further promoted by the fact that most of the individual mechanoreceptors in spinal and paraspinal structures produce excitatory discharges when stimulated (18,22). Currently, no clear consensus exists on whether spinal manipulative therapy evokes an overall excitatory or inhibitory response from motor neurons.

An appropriate tool for evaluating of the alpha motor neuron pool excitability is “Tibial Nerve Hoffmann Reflex” (H-Reflex) (23). H-reflex, which is in widespread use, is an Achilles muscle stretch reflex electrophysiologically recorded without using muscle spindle. This reflex in clinical settings is generated by recording over the gastrocnemius and soleus muscles and stimulating the tibial nerve in the popliteal fossa. Performing this test, however, needs to be very careful. It is a submaximal elicited a reflex response. The duration of the stimulus is 1 ms, then the stimulus needs to be slowly increased by 3- to 5-mA increments. It should be mentioned that the patient needs to be relaxed while receiving the stimulus. In addition, the frequency of the stimulus must be less than once per second in order to prevent habituation of the response. H-reflex tends to be consistent with regard to latency and morphology. It takes place when the motor response over the gastrocnemius as well as soleus is submaximal. Along with the gradual increase in the stimulus current, the H-reflex reaches its highest amplitude. As the motor response becomes maximal, the H-reflex extinguishes.

Several researchers have carried out the evaluation of its sensitivity and specificity regarding the lumbosacral radiculopathies, and a range of sensitivity between 32% and 88% has been generally reported.

In case of H-reflexes in lumbosacral S1 radiculopathy, however, the specificity has been reported to be 91%. Separation of S1 radiculopathy from that of L5 is facilitated by H-reflex as the L5 radiculopathy tends to have a normal reflex. H-reflexes are useful for assessing for demyelinating polyneuropathy, cauda equina syndrome, and for confirminging a sciatic neuropathy. It should be noted that delayed or decreased amplitude of H-reflex can happen wherever there are lesions along its course. These include S1 root, sciatic nerve, and the lumbosacral plexus. Investigation on H-reflex of other nerves presents a bigger challenge to elicit. Hence, in the arena of clinical practice, they are barely used (24).

The tibial nerve H-reflex response provides a neurophysiologic index of alpha motorneuron pool excitability as a consequence of lumbosacral spinal manipulation, Ia afferent from the triceps surae muscle activate the alpha motor neuron pool of the lumbosacral spine (22,25).

Thus, the amplitude of the tibial nerve H-reflex response is reduced or enhanced if activation of proprioceptive afferents after lumbosacral spine manipulation inhibits or excites the alpha motorneuron pool, respectively. Also can be used the H/M max amplitude ratio which determine the stimulated alpha motorneuron pool, by Ia afferents as functional index for alpha motorneuron stimulate rate. Up to now, studies in this field have been reviewed the effect of the manipulation on H- reflex, more than anything else in healthy subjects and the small sample size.

Materials and Methods

This study was quasi-experimental. During the years 2011 and 2012, 58 patients (with LBP) aged from 20 to 60 years who referred to physical medicine and rehabilitation clinics that had no exclusion criteria were evaluated prospectively for lumbosacral manipulation efficacy on the alpha motor neuron activity. Exclusion criteria were included: major diseases such as cardiovascular, respiratory and renal diseases, neoplasms, degenerative vertebral lesions, fractures and dislocation of vertebra, arthritis, quada equine syndrome, aneurysm of the abdominal aorta, past history of vertebral surgery, osteoporosis, pregnancy, past history of manipulation during last 6 months, and Body Mass Index (BMI)> 32. Demographic information questionnaire included age, sex, the duration time of low back pain. The patients were examined, and then, tibial nerve H-reflex and M-wave were recorded according to the standard technique described by Dumitru_textbook. Briefly, this technique is that the patient lays on a bed in a prone position, so his legs hanging over the edge of the bed. The active recording electrode is placed at the middle point of the line connecting medial malleolus to the mid popliteal fossa. The reference electrode is applied over the triceps surae tendon at the lowest part. The ground is placed between the stimulating and active electrodes proximal to E_1. Stimulating electrodes are applied directly over the nerve on the popliteal fossa. The cathode is placed at the mid popliteal fossa whereas the anode is placed at the distal side. Instrument setup was included: duration of stimulation=1 m, sweep=10 ms/div, the sensitivity of amplifier=0.5 mv/div and stimulation frequency=0.5 Hz. The optimal stimulation intensity was defined as the voltage that evoked the maximal H-reflex amplitude. At this optimal intensity, all subjects received three stimulations, the corresponding M-wave responses and H-reflexes were recorded. In order to prevent low-frequency depressions in the H-reflex, simulations were provided at 10-second intervals. Subjects were urged to keep their head, arms, and lower extremities still. They were also not allowed to talk and were asked to fix their eyes on a target. This was done to minimize changes in H-reflex response because of muscle contraction, joint position, or tonic reflexes.

After H-wave recording, an experienced clinician performed the high-velocity, low-amplitude lumbosacral manipulation procedure, which was delivered bilaterally and then immediately was rechecked H-reflex and maximal M-wave without displacing the patient. These procedures consist of “side-posture” lumbar spine manipulation. The thrusts or manual forces to the zygapophysial joint were provided the end of the physiologic range of joint motion. These thrusts were then extended into the paraphysiologic zone of joint motion. All data were collected and analyzed with SPSS software (version 20).

Results

Fifty-eight participants included 19 men and 39 women. Mean age of participants was 44.24 years (SD=10.51), and means and standard deviation for BMI and symptoms’ duration (for LBP) were 26.82 (3.14) kg/m^2 and 29.12 (32.25) months, respectively.

There were no significant changes in M- wave amplitude and latency of the left, right and in a total of both lower limbs after manipulation compared with the one of before (Table 1 and 5).

Table 1. Comparison of M wave parameters between before and after manipulation

M wave parameters	Before manipulation Mean(SD)	After manipulation Mean(SD)	*P*
Right Latency (ms.)	4.48(0.72)	4.52(0.61)	0.468
Left Latency (ms.)	4.53(0.50)	4.52(0.48)	0.371
Right Amplitude (mvol.)	7.79(1.75)	7.67(1.87)	0.199
Left Amplitude (mvol.)	8.31(1.77)	8.49(1.68)	0.708

The latency of the H-wave increased after manipulation procedure on the left and right lower limbs and also in total of both lower limbs, compared with pre-manipulation stage; however, they were not statistically significant, its amplitude was increased as statistically significant, though (Tables 2 and 5). H/M_{max} amplitude ratio after manipulation decreased, compared with the previous manipulation on the left, right and also in total of both lower limbs so that the difference was statistically significant (Tables 3 and 5).

The results obtained from all variables in the right lower limbs were compared with the left that found no statistically significant difference between the two limbs (Table 4).

Table 2. Comparison of H-reflex parameters between before and after manipulation

M wave parameters	Before manipulation Mean(SD)	After manipulation Mean(SD)	*P*
Right Latency (ms.)	28.8(1.67)	28.9(1.95)	0.509
Left Latency (ms.)	28.62(1.85)	28.67(1.84)	0.520
Right Amplitude (mvol.)	1.65(0.93)	1.38(0.89)	<0.001
Left Amplitude (mvo.l)	1.52(0.83)	1.34(0.77)	0.004

Table 3. Comparison of H/M amplitude ratio between before and after manipulation

H/M amplitude ratio	Before manipulation Mean(SD)	After manipulation Mean(SD)	*P*
Right	0.218(0.118)	0.118(0.119)	<0.001
Left	0.192(0.112)	0.163(0.098)	<0.001

Table 4. Comparison between all results obtained of all variables in the right lower limbs with left lower limb

	Before manipulation Mean(SD)	After manipulation Mean(SD)	*P*
M latency(ms.)	0.037(0.395)	-0.012(0.102)	0.337
M amplitude(mvol.)	-0.122(0.717)	0.181(1.164)	0.098
H latency(ms.)	0.060((0.267)	0.055(0.649)	0.966
H amplitude(mvol.)	-0.267(0.60)	-0.181(0.46)	0.434
H/M amplitude ratio	0.030(0.091)	-0.029(0.051)	0.95

Table 5. Comparison H-reflex and M wave parameters between before and after manipulation

N=116	Before manipulation	Post manipulation	*P*
M wave latency(ms.)	4.51(0.61)	4.52(0.55)	0.712
M amplitude(mvol.)	8.05(1.77)	8.08(1.82)	0.442
H-reflex latency(ms.)	28.73(1.80)	28.78(1.89)	0.354
H-reflex amplitude(mvol.)	1.58(0.88)	1.36(0.82)	0.000
H/M amplitude ratio	0.20(0.11)	0.17(.10)	0.000

Discussion

The results of the present study indicated that the lumbosacral manipulation reduces H-reflex amplitude of the tibial nerve and H/M $_{max}$ amplitude ratio prior to manipulation, thereby inhibiting alpha motor neurons. According to the results, amplitude and latency of the M wave after manipulation did not have statically significant difference than the before, which indicates that the stimulating and recording conditions are the same, before and after the manipulation. In addition, manipulation did not have a significant effect on the H-reflex latency. This is due to following stimulation of any number of alpha motorneurons and receiving signals from the most rapid alpha motor neuron and then producing H- reflex can be found its latency. Consequently, the latency of the H-reflex does not indicate the alpha motorneurons excitability and is not affected by the manipulation.

Manipulation can reduce the activity of alpha motorneurons by a variety of mechanisms. A proposed mechanism is “after effects,” which mean the changes in the sensory discharge rates, mostly in I_a afferents which tend to occur responding to a change in muscles’ history of activation and length.

After effects refer to changes in sensory discharge rates, predominantly in I_a afferents, that occur in response to an alteration in a muscle’s history of activation and length changes. In addition, manipulation alters the position and posture of the muscle spindle receptors. Another mechanism is post-activation depression. Spinal manipulation is equivalent to rapidly applying a mechanical strain to the trunk. Mechanical strain of the ligament–muscular system of the spine evokes reflex activation of paraspinal muscles. Then due to the discharge of neurotransmitters, the monosynaptic arc of the H- reflex is inhibited.

Spinal manipulation, also, is capable of starting afferent discharges from mechanoreceptors as well as free nerve endings in the annulus fibrosus, zygapophyseal joint capsule, and ligaments of the spine that synapse on inhibitory interneurons, which in turn inhibit motor neurons.

Herzog reported the observation of one subject with back pain which was deemed to have baseline (pre-manipulation) hypertonicity of paraspinal musculature, as evidenced by elevated surface electromyographic amplitudes. In that subject, it was observed short-term reflex inhibition after manipulation that is consistent with the current study (26).

A similar study by Orakifar indicated that sacroiliac joint manipulation inhibits alpha motoneuronal activity. This study was consistent with our results. Of course, this inhibitory effect was short-term and lasted only for 20 seconds after manipulation. However, in this study, it has been shown that the amplitude of the M wave responses were reduced; a finding which was not confirmed in our study (27). Similar results reported by Dishman that spinal manipulation profoundly but transient influences on the H-reflex amplitude in 17 healthy subjects (23).

Dishman, in another study, reported similar results stating that spinal manipulation procedures gave rise to transient suppression of motorneuron excitability. Besides, the lumbar spine SM seems to result in greater attenuation of motor neuron activity compared the one of the cervical region. Furthermore, the attenuation of the tibial nerve H-reflex amplitude was proportionally greater than that of the median nerve, which took place after cervical spinal SM. Therefore, manipulation has a segmental effect on alpha motor neurons (22). These findings are in line with the results of our study.

Suter's study (in 200) reported that H-reflex amplitude did not demonstrate any significant changes among healthy subjects who received manipulation to the Sacroiliac joint. Of course, this holds true if the H-reflex testing and the related treatment were carried out in the same position. In other words, there was no movement in the position of the subject within the span of the experiment. In spite of this, patients who suffered from low back pain demonstrated changes in motorneuron excitability after SI joint manipulation. Suter *et al.*, concluded that there is sensitivity to movement/repositioning in the H-reflexes having applied spinal manipulation. In addition, post-manipulation H-reflex depressions which were documented in other investigations were movement artifacts and not treatment effects. The results obtained from subjects with low back pain were consistent with our study (28).

Due to the fact that: lumbosacral manipulation produces attenuation of motorneuron activity in subjects with low back pain, it can be concluded that manipulation reduces muscular tonicity through inhibiting the motor neuronal excitability and can disrupt "pain-spasm-pain" cycle, consequently, to be effective in the treatment of back pain.

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