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ORIGINAL CONTRIBUTION

Gross Range of Motion in the Cervical Spine: The Effects of Osteopathic Muscle Energy Technique in Asymptomatic Subjects

Denise K. Burns, DO
Michael R. Wells, PhD

Muscle energy technique is an established osteopathic manipulative intervention often used to treat somatic dysfunctions of the spine. There are little objective data to demonstrate its efficacy, however. To determine the efficacy of this osteopathic manipulative technique, the authors compared active cervical range of motion among asymptomatic young and middle-aged adults (n=18) before and after this treatment protocol, comparing those results against matched control subjects (n=14) who received sham manipulative treatment. Range of motion was measured in three planes (flexion/extension, lateral bending, rotation) on all subjects (N=32) using a motion-analysis system. Multiplanar gross cervical motion restrictions were diagnosed in this asymptomatic population. In the treatment group, cervical long restrictor muscles were treated with the muscle energy technique in the sagittal, frontal, and horizontal planes. The control group had relative restrictions addressed by means of a sham manipulative treatment protocol in which the barriers to motion were not challenged therapeutically. The muscle energy technique produced a significant increase in overall regional cervical range of motion in the treatment group (approximately 4 degrees) when compared with control subjects ($P<.001$). Significant differences were also observed in the magnitude of change in the three planes of movement (rotation, $P<.002$; lateral bending, $P<.01$), with flexion/extension being the least affected ($P=.2$). These data demonstrate that the application of the muscle energy technique can produce acute increases in the active cervical range of motion in asymptomatic subjects.

From the Stanley Schiowitz Department of Manipulative Medicine (Burns) and the Department of Biomechanics and Bioengineering (Wells) at the New York College of Osteopathic Medicine of New York Institute of Technology in Old Westbury.

Address correspondence to Denise K. Burns, DO, Stanley Schiowitz Department of Manipulative Medicine, New York College of Osteopathic Medicine, New York Institute of Technology, PO Box 8000, Old Westbury, NY 11568-8000.

E-mail: drdenise@optonline.net

In the revised *Glossary of Osteopathic Terminology*,[1] the term *somatic dysfunction* is defined as "impaired or altered function of related components of the somatic (body framework) system: skeletal, arthrodial, and myofascial structures, and related vascular, lymphatic and neural elements." Somatic dysfunction of the cervical region of the spine often results in increased muscle tension, sensitivity changes (eg, tenderness), asymmetry, and restriction of range of motion. Although many symptoms of somatic dysfunction, such as sensitivity changes, are subjective and are reported by patients, asymmetry and tissue tension can be found through palpatory examinations and, to a certain extent, by mechanical measurements. However, the restriction of range of motion, both active and passive, can be easily measured by conventional means.

Fred L. Mitchell, Sr, DO, developed the muscle energy technique, then called the "muscle energy treatment." Dr Mitchell wrote two papers[2] in which he credited T.J. Ruddy, DO, for his inspiration. Dr Ruddy used a method called osteopathic rhythmic resistive duction therapy to treat head and neck injury and pain. In resistive duction technique, the patient's force is constant against a rhythmic pressure applied by the osteopathic physician at a rate approximating the patient's pulse.[3] Ruddy believed this osteopathic manipulative (OM) technique helped with circulation and muscle tone.

For the present study, the muscle energy procedure was used to lengthen potentially shortened cervical muscles and fascia to normalize the gross cervical range of motion. Furthermore, regional range-of-motion barriers (flexion/extension, sidebending, rotation) of the cervical spine were increased by investigators using muscle energy technique.

Investigators in the present study used isometric muscle contraction to increase treatment subjects' gross cervical range of motion. It is postulated that segmental motion is limited by hypertonic short restrictor muscles and possibly arthroidal locking and that regional cervical motion restrictions are caused by shortened, hypertonic long restrictor muscles of the cervical spine.[3] Lengthening these larger muscle groups may help to restore gross physiologic range of motion in the neck. Distortion of articular relationships and motion loss are thought to result in reflex hypertonicity of the musculature crossing the dysfunctional joint. This increase in muscle tone may tend to compress joint surfaces and result in "hydraulic locking" of the articulation. Restoration of motion to the articulation can result in a "reseating" of the distorted joint relationships with reflex relaxation of the previously hypertonic musculature.[4]

Methods

Subjects

Subjects were recruited from first-year medical students and from faculty and staff at New York College of Osteopathic Medicine of New York Institute of Technology (NYCOM/NYIT) in Old Westbury. The present study's protocol was approved by the institutional review board at NYCOM/NYIT. Informed consent was requested from and provided by all study participants.

Using inclusion and exclusion criteria, investigators screened potential subjects for any known medical condition involving the neck or cervical spine, including previous trauma, chronic conditions (eg, arthritis), acute undiagnosed pain, or hypermobility. First-year medical students were recruited to reduce the possibility of previous subject exposure to muscle energy techniques. No subjects were excluded from the study as a result of the exclusion criteria and all subjects met the requirements of the inclusion criteria, which required confirmation that they were unfamiliar with this OM technique.

Investigators randomly assigned subjects to either the treatment or control group by asking them to draw a slip of paper with the group assignment printed on it from a box. Subjects then handed that slip of paper to the principal investigator (PI). This assignment process was chosen to prevent group assignments based on personal relationships or biases. Subjects were blinded to treatment type and the measurements obtained. The PI was blinded to the measurements of each subject.

All OM and sham manipulative treatments were performed primarily in the afternoon at a biomechanics laboratory, where all biomechanical analysis was also performed. All OM and sham manipulative treatments were delivered by the PI, who is board certified in family practice and osteopathic manipulative treatment (OMT) and has been in medical practice for 12 years.

In the treatment group, the muscle energy technique was applied to subjects' cervical spines according to the basic procedure described in the "Interventions" section. Each subject in the treatment group received this OM treatment in each of the three planes of motion (ie, flexion/extension, lateral bending, rotation). The cervical spine was brought to the barrier of motion in each of these planes. Subjects were then asked to push their heads into the direction opposite that of the barrier (ie, relative freedom). The PI provided isometric resistance for 3 to 5 seconds, after which subjects were asked to relax their muscles completely and a new barrier of motion was engaged by the PI. Three repetitions were performed as dictated by the technique protocol as well as the study design and are further described in the "Interventions" section.

The sham manipulative treatment, also performed by the PI, consisted of passively moving subjects' cervical spines along one of the three planes of motion at a time. In the control group, subjects' cervical spines were brought to the soft tissue barrier of motion, held in that position for 3 to 5 seconds, and repositioned into a new barrier three times. This was done in both directions in each plane of motion, and all three planes were addressed.

Interventions

The PI delivered muscle energy treatment to subjects in the treatment group using the following steps:

(1) The PI localized the joint or body tissues into the position of initial range of motion resistance to a specific movement (ie, flexion/extension, sidebending, and rotation).
(2) The subject was instructed as to the amount (ounces to a few pounds) and duration (3 to 5 seconds) of contractile force to use when instructed to do so.
(3) The PI instructed the subject to push his or her head and neck into the appropriate direction of movement.
(4) The PI provided an isometric counterforce until she perceived an appropriate muscle contraction in the subject. This step generally required between 3 and 5 seconds, but the duration the isometric counterforce was applied by the PI varied with the size of the muscle being treated.
(5) The subject was directed to gently cease contraction while the PI simultaneously matched the decrease in the subject's force with an equivalent amount of isometric force.
(6) The PI allowed the subject to relax for 3 to 5 seconds. At the same time, the PI monitored the subject for tissue relaxation (ie, decrease in muscle tonicity).
(7) The PI engaged a new barrier of motion in the subject. The reduction of tension in the subject's tight muscle allowed it to be lengthened passively.
(8) The PI quantitatively measured and qualitatively reevaluated the subject's range of motion.
(9) Steps 1 through 8 were repeated two to four times, as part of the treatment process.

The quality of subject response often peaked at the third excursion with diminishing returns thereafter. Optimal positioning was determined as symmetrical position of the region (sidebending or rotation) of approximate normal range of motion (flexion/extension).

The PI delivered sham manipulative treatment to subjects in the control group using the following steps:

(1) The PI localized the joint or body tissues into barrier of motion in one plane of motion (ie, flexion/extension, sidebending, and rotation).
(2) The PI approximated the subject's soft tissue barrier gently, stretching through it passively and continuously for 3 to 5 seconds.
(3) The subject's cervical spine was then brought to a neutral position and held there for 3 to 5 seconds.
(4) The PI allowed the patient to relax and then took up the

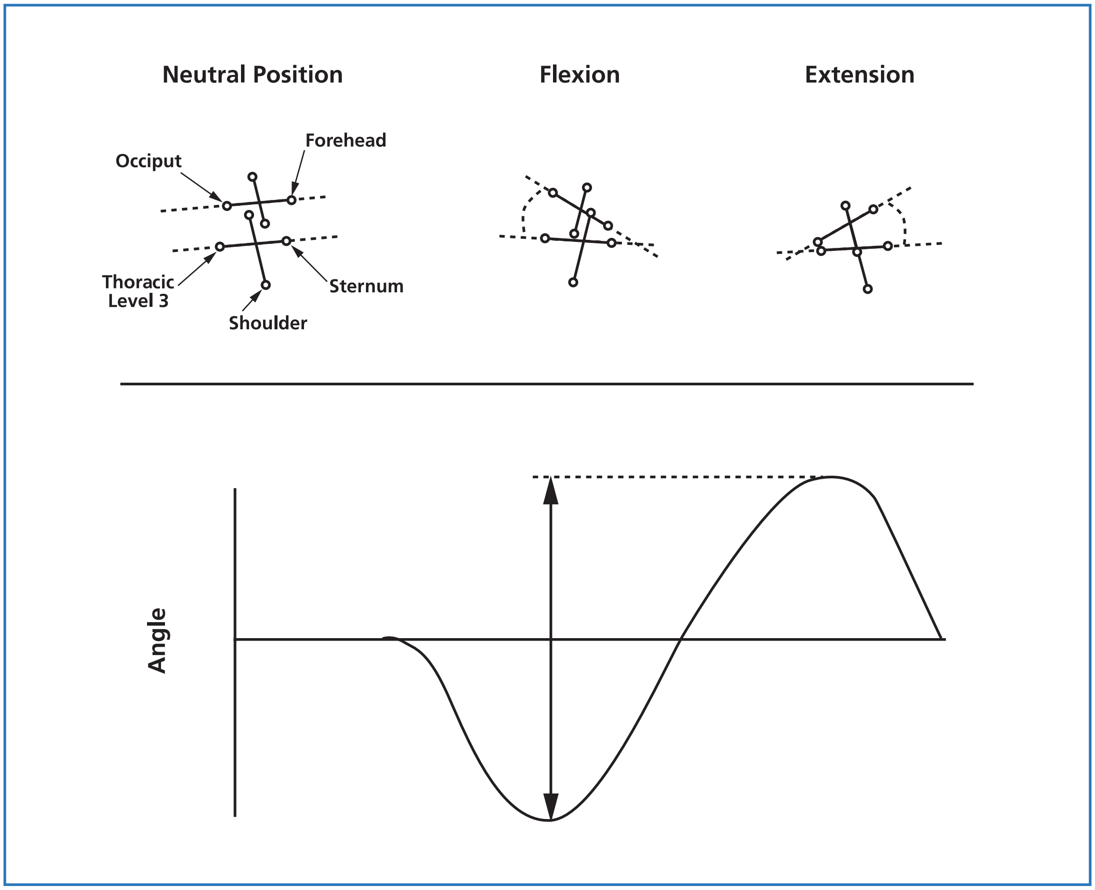

Figure 1. *Measurements used for osteopathic manipulative muscle energy technique. The positioning of the eight markers and the angles detected during the flexion and extension plane are presented in the top section of the figure. A graph was then generated from this angle to demonstrate the corresponding range of motion measurement.*

soft tissue "slack" permitted by the sham procedure.

(5) The PI engaged a new barrier of motion in the subject, repeating steps 1 through 5 for a total of three repetitions.

(6) A passive stretch was completed at the end of the third stretch. This step was repeated for all planes of motion in both directions.

(7) The PI quantitatively measured and qualitatively reevaluated the subject's range of motion.

The sham treatment consisted of passively moving each subject's cervical spine into one plane of motion. The cervical spine was then brought to its soft tissue barrier of motion in this plane: three times into one direction and subsequently three times into the other direction. This same sham procedure was carried out in all three planes of motion.

Measures

For both study groups, investigators measured subjects' active cervical range of motion pretreatment and immediately posttreatment (ie, 1 to 2 minutes after intervention). Measurements were conducted using a three-dimensional motion-analysis system (Peak Performance Technologies Inc, Centennial, Colo) with data acquisition/motion analysis software (version 6.1.4; Peak Motus, Centennial, Colo). Reflective markers were placed on subjects' heads at 90-degree angles (center of the forehead, above each ear, and on the occiput) using an elastic band as support. Markers on the body were placed on the sternum, on the spinous process at approximately thoracic level 3, and on the distal point of the acromial process of each shoulder. The position for each marker was indicated with a washable ink pen for accurate replacement. Measurements taken consisted of the range of motion in the cervical spine before and after intervention in all three planes of motion. Range of motion was computed from the angles projected on a plane by segments generated in a spatial model based on marker placement *(Figure 1)*.

This process allowed for the elimination of extraneous movements that might be attributed to changes in the subject's trunk position rather than changes in actual cervical range of motion. Cervical flexion and extension were measured as a two-dimensional angle projected on a sagittal plane by the extension of the segment between the marker on the

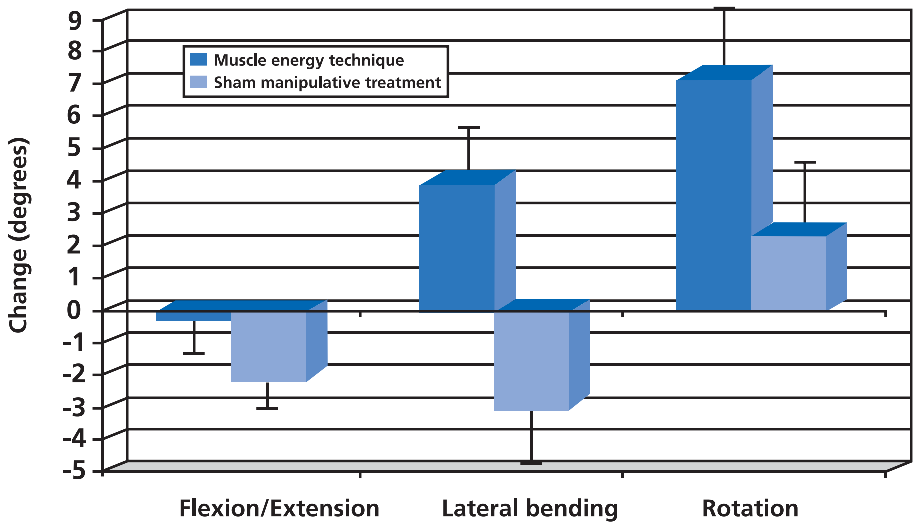

Figure 2. *Bar chart describing changes in subjects' range of motion between pretreatment and posttreatment measurements for both intervention groups (ie, osteopathic manipulative treatment [OMT] and sham manipulative treatment) in the three planes of motion examined. Clinically and statistically significant differences were found both within and between the two study groups.*

For subjects in the OMT group who received treatment with the muscle energy technique, a clinically significant increase in range of motion was found when pre- and posttreatment results were compared for the lateral bending and rotation phases of the study protocol. In addition, a significant difference (P=.002) was found within this study group between pretreatment and posttreatment range of motion.

For subjects who received sham manipulative treatment, a clinically significant difference was found overall in pre- and posttreatment comparisons, but especially during the flexion/extension phase of the study protocol (ie, significant reduction in range of motion).

Between the two study groups, there was a significant difference between the treatment and the control groups during the lateral bending phase of the study protocol (P<.01) and during rotation (P<.03).

sternum and the marker at cervical level 7 (C7) as well as the segment between the forehead marker and the C7 marker. Movement into flexion created a negative change in degrees whereas extension created a positive change in degrees.

Cervical lateral bending was measured between the two line segments, one connecting the two markers placed above the subjects' ears and the second connecting the markers placed on subjects' shoulders. The angle between these two segments projected onto a frontal plane was then calculated.

Cervical rotation was measured by calculating the two-dimensional-angle projected on a horizontal (transverse) plane of the line segments created between the markers on the front and back of the head and the markers on the shoulders.

Range of motion was calculated as the total angular displacements forward-to-backward in a sagittal plane (flexion/extension) and the total of left and right movement (lateral bending and rotation).

During data collection, subjects were seated on a bench and directed to look at a marker directly in front of them at the end of the room. The measurements taken while subjects were positioned in this way were recorded as the neutral position before the intervention protocols.

The verbal instructions given to subjects were standardized. After neutral positioning was measured, subjects were then asked to move their heads in one of the three planes of motion, starting to the right and on each side. A total of at least four repetitions were collected. Motion characteristics were addressed in the same order: pretreatment, during intervention, and posttreatment for both groups.

For both groups, flexion and extension in the sagittal plane were addressed first, followed by the frontal plane (lateral bending), and then rotation.

Data Analysis

The data collected consisted of a full range of motion in degrees in each of three planes (flexion/extension, lateral bending, and rotation) before and after intervention protocols with at least three repetitions. For comparisons between study groups, the magnitude of difference in range of motion between pretreatment and posttreatment was tested with an analysis of variance statistical design.

This statistical method was performed to examine potential differences between treatments in ranges of motion, planes of motion, and interactions. The data were then examined for potential differences within subjects for each plane and intervention using a paired *t* test. The paired *t* test determines whether paired sets differ significantly from each other under the assumptions that the paired differences are independent and distributed normally and identically. The *t* test identified a variability within subjects in response to intervention and the potential sensitivity of each plane to the assigned intervention.

Results

Thirty-two subjects of both sexes (20 women, 12 men) aged 20 to 49 years (average age, 26.81 y; median age, 25 y; 25±6.5 SD) agreed to participate in the study. Eighteen (56%) subjects were randomly placed in the treatment group and received the osteopathic muscle energy technique. Fourteen (44%) subjects were randomly placed in the control group and received sham manipulative treatment.

All values are expressed as mean±SE. An evaluation of pretreatment range of motion showed no differences between groups at the beginning of the experiment ($P<.70$). Average pretreatment range of motion was 71.5 degrees ± 1.6 degrees for flexion/extension, 89.2 degrees ± 3.0 degrees for lateral bending, and 137.6 degrees ± 2.2 degrees for rotation.

Examination of the magnitude between pre- and post-treatment range of motion among all motions demonstrated significant differences ($P<.001$; *Figure 2*) between the treatment group (3.7 degrees ± −1.0 degrees) and the control group (−1 degree ± 0.9 degrees), however. The averages suggest that, in control subjects, the range of motion decreased slightly with sham manipulative treatment, whereas in the muscle energy treatment group, the range of motion increased.

In addition, analysis revealed significant differences in the magnitude of change in range of motion for the different movements examined ($P<.001$; *Figure 2*). In an isolated analysis of flexion/extension range of motion changes, there was no significant difference between treatment and control subjects ($P=.20$). However, within the sham manipulative treatment group, the decrease in range of motion was significant (−2.2 degrees ± 0.9 degrees; $P=.03$; paired *t* test), whereas within the muscle energy treatment group, no change in range of motion was seen (−0.3 degrees ± 1.2 degrees; $P=.83$).

An isolated analysis of lateral bending range of motion changes showed a significant difference between the control and treatment groups ($P<.01$). Within groups, paired *t* tests suggested that sham manipulative treatment resulted in a significantly worse range of motion in lateral bending (−3.1 degrees ± 1.4 degrees; $P=.04$), whereas muscle energy treatment significantly increased subjects' range of motion (3.9 degrees ± 1.4 degrees; $P=.03$). For alterations in cervical rotation range of motion, an isolated analysis showed a significant difference between treatment and control groups ($P=.03$). Within groups, control subjects did not demonstrate significant change (2.4 degrees ± 2.0 degrees; $P=.26$) when compared with pretreatment ranges, whereas treatment subjects showed significant improvement in range of motion (7.2 degrees ± 1.9 degrees; $P=.002$).

Comment

These data demonstrate that it is possible to increase the active range of motion in the cervical region of asymptomatic subjects using the OM technique called muscle energy. The changes in range of motion were not large (approximately 4 degrees), but were consistent enough to produce statistically significant results (flexion/extension, $P=.20$; lateral bending, $P=.01$; rotation, $P=.03$). A limited change might be expected in a population of predominantly young, healthy subjects. There appeared to be a differential sensitivity of the three planes of motion to treatment, with flexion/extension not changing with treatment and rotation responding robustly.

To some extent, this result may reflect an interaction of the age of the subjects and the methods of measurement. Most of the subjects were young and had a large gross range of motion of the neck, such that in flexion/extension, the physical barrier of the chest became a limitation.

A similar, but less frequent, problem was encountered with lateral bending and the shoulder.

Rotation, the plane in which the largest changes were seen, would not have similar restrictive barriers. This may have reduced the potential for change with treatment.

The reasons for a significant decrease in range of motion in the sham manipulative treatment group for flexion/extension and lateral bending are unclear. Muscle fatigue may have been a contributing factor. Perhaps the protocol used for sham manipulative treatment in the present study induced a cervical muscular strain by repetitively bringing the neck to its physiologic barrier to motion in several different planes of motion. The stretch induced in control subjects may have initiated a muscle spindle response leading to reflex muscle contraction. This difference was not present, however, in rotation, in which the control group showed a trend toward an increase in range of motion (2.4 degrees+2.0 degrees; $P=.26$).

There was a significant decrease in the range of motion in control subjects (flexion/extension, −2.2 degrees +0.9 degrees, $P=.03$) and a slight trend of a decrease in the range of motion in treated subjects (−2.2 degrees +1.2 degrees, $P=.83$). These latter results would argue against some volitional bias of the subjects in response to an interpretation of treatment, or the placebo effect, which has been implicated in spinal manipulation.[5]

Because potential restrictions or somatic dysfunctions were not evaluated in participants for the present study, the mechanism of improvement in range of motion was not addressed. Results were obtained from a relatively healthy, asymptomatic population. Study subjects may have had subacute—as opposed to acute—somatic dysfunction before treatment with this OM technique. The study results reflect this fact with the rotational component being the most restricted component and flexion/extension having a negligible restrictive component. However, our results are generally consistent with the proposed basic mechanisms of action for the muscle energy technique and its use to treat somatic dysfunctions that result in cervical motion restrictions.[6]

This particular OM technique may be useful in the treatment of numerous clinical syndromes, such as cervicogenic headache,[7] nerve compression syndromes,[8] acute and chronic neck pain from motor vehicle accidents, or minor trauma to the neck.[9] There seems to be an inverse correlation between an increase in cervical range of motion and a decrease in neck pain.[6] Cervical manipulation was shown to be much safer when compared with the use of nonsteroidal anti-inflammatory drugs in the treatment of neck pain by a factor of over 100%.[10] Muscle energy technique may be applied in the treatment of somatic dysfunctions not only of the spine, but also of the ribs, extremities, and pelvis.[11]

Serious complications associated with cervical manipulation, such as cerebrovascular accidents, have been shown to occur rarely.[12]

The osteopathic physician must take care to customize the use of the muscle energy technique to the patient and the body region treated. In other words, the area under treatment should govern the amount of force and counterforce applied by the osteopathic physician. Pounds of treatment force may be considered when treating large muscles, as in the hip, but ounces of treatment force should be considered when treating weaker, shorter, and smaller muscles, such as those between the cervical vertebrae.[11] Further study is necessary to address issues related to the efficacy and refinement of the muscle energy technique as it is used in the treatment of specific vertebral somatic dysfunctions—and in the process of optimizing triplanar motion.

Although control subjects in the present study were asymptomatic, they had a considerable degree of somatic dysfunction. Perhaps there is a threshold of somatic dysfunction and resulting pain that the body is able to tolerate without nociceptors triggering the neuromuscular reflexive cascade that follows, causing symptoms that become recognizable as such to the patient. Perhaps the body has the innate ability to compensate finitely for the presence of subacute strains and stresses.

The duration of benefit from OMT with the muscle energy technique may also be an important area for future study. A previous study[13] noted that there may be a limited duration of benefit in the increase of cervical range of motion following different OM techniques.

Conclusion

The use of the muscle energy technique to increase cervical range of motion in normal, asymptomatic subjects was examined in this sham-controlled study. Although differences were observed in the efficacy of this OM technique as applied in the three planes of motion examined, the application of this procedure produced a statistically significant, acute increase in overall cervical range of motion in the treatment group. The results of the present study are an important initial step in exploring the efficacy and appropriate use of the muscle energy technique in the treatment of somatic dysfunctions of the cervical spine.

This research provides evidence that the muscle energy technique may be a valuable and useful tool in clinical practice and is consistent with the current use by osteopathic physicians of the muscle energy technique in the treatment of cervical spine dysfunctions.

Future studies may assess the quality of cervical muscle energy treatment on one or more documented segmental cervical vertebral motion restrictions in symptomatic patients.

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