Effects of Comprehensive Osteopathic Manipulative Treatment on Balance in Elderly Patients: A Pilot Study

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Context: Falls, many of which are caused by balance problems, are a leading cause of injuries in elderly persons. Few studies have investigated osteopathic manipulative treatment (OMT) for patients with balance problems.

Objective: To test whether an OMT protocol with an emphasis on cranial manipulation can improve vestibular balance control structures and postural stability in a healthy elderly population.

Design: A pilot prospective clinical trial.

Setting: Research laboratories of the University of North Texas Health Science Center Texas College of Osteopathic Medicine in Fort Worth.

Patients: Forty healthy elderly patients aged 65 or older were enrolled and separated into an OMT group and a control group. Owing to the recruitment process and limited time for the study, the first 20 patients to enroll were in the OMT group, and the next 20 were in the control group. Patients were excluded if they had a condition that could impair balance.

Intervention: The OMT protocol comprised 7 OMT techniques applied weekly by the same osteopathic physician before balance tests. Patients in the control group received no treatment.

Main Outcome Measures: Patients were asked to stand on a force plate and to perform 3 balance tests: (1) eyes open, (2) eyes closed, and (3) a modified Romberg test. The center of pressure between their feet was recorded for 30 seconds. The average center of pressure displacement for each test was used to determine anteroposterior (AP) sway and mediolateral (ML) sway. Balance tests were performed each week for 4 weeks. Tests were performed at the same time of day as the first test.

Results: Changes in AP sway values between visits 1 and 4 were as follows: eyes open, -0.72 and 0.75 mm for the control and OMT groups, respectively; eyes closed, -0.49 and 0.44 mm; and Romberg test, -0.17 and 0.52 mm. The changes in ML sway values between visits 1 and 4 were as follows: eyes open, -0.58 and 0.07 mm for the control and OMT groups, respectively; eyes closed, -0.21 and 0.03 mm; and Romberg test, -0.15 and 0.39 mm. The OMT group had significantly reduced sway for the eyes-open test after 4 visits ($P=.001$).

Conclusion: The OMT protocol used in the present study improved the postural stability of healthy elderly patients, as measured by changes in sway values. (ClinicalTrials.gov number NCT01153412)

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It seems that illness and disability do not simply progress in 1 direction from disease process to disability to handicap; rather, the process is a complex interaction between health conditions, body structure and function, environmental and personal factors, and limitations in activity and participation. Biologic, behavioral, environmental, and socioeconomic risk factors can all contribute to falls.\textsuperscript{1(p4)}

Injuries sustained because of a fall in old age are almost always more severe than when similar injuries occur at a younger age. Therefore, the incidence of falls and related injuries is a concern of those who treat and provide care for elderly persons. Approximately 28% to 35% of persons aged 65 years or older fall each year,\textsuperscript{1(p3)} and this rate increases to 32% to 42% for those older than 70 years.\textsuperscript{1(p1)} It is estimated that 30% to 50% of individuals living in long-term care institutions fall each year.\textsuperscript{1(p1)} Falls are a leading cause of fatal and nonfatal injuries in older adults, causing even more deaths than either pneumonia or diabetes.\textsuperscript{2,3(p1020)} More than one-third of all patients admitted to hospitals for injuries are elderly, and
more than 80% of their injuries are caused by falls. Falls may also result in postfall syndrome, which includes dependence, loss of autonomy, confusion, immobilization, and depression, leading to further restrictions in daily activities.

Many of the hip fractures sustained in elderly persons in the United States as a result of falls are related to balance disorders. Dizziness is reported to be the most common complaint for patients older than 75 years. A 2010 Dutch national study showed an 8.3% incidence of dizziness in general practice patients aged 65 years or older, with a higher prevalence in women than in men and in those aged 65 years or older. Falls are frequently unreported to medical professionals, and many may be associated with other medical factors, such as diabetes mellitus, which is highly prevalent in adults older than 65 years. This combination of old age and diabetes may increase the risk for injuries due to the progression of peripheral neuropathy and visual impairment. Estimates of the prevalence of diabetes mellitus range from 12% to 25%, depending on the ethnic group. Older persons with diabetes mellitus are also thought to have an increased risk of frailty and functional disability, visual impairment, and peripheral neuropathy. All of these factors combined with diabetes mellitus may exacerbate dizziness. Medical expenses related to falls amount to more than $27.3 billion annually in the United States, and this figure is projected to climb to $43.8 billion annually by 2020. Treatment methods to help reduce the incidence of falls in the elderly population are thus a priority in geriatric medicine.

Postural stability and balance are defined as the body's ability to return to a state of equilibrium after a perturbation. Many medical and age-related pathologic conditions lead to postural instability. Analysis of postural stability is important not only for increasing knowledge of the postural control system but also for assessing and documenting rehabilitative treatments. When the postural control system is compromised for any reason, its improvement is an important goal of rehabilitation.

It is generally thought that patients who show more than a certain degree of anteroposterior (AP) and mediolateral (ML) sway have poor balance. A force platform or comparable apparatus to measure body sway during quiet standing is a reliable method for assessing postural stability. Laughton et al used a balance platform to evaluate sway in elderly patients and found that "elderly fallers" had significantly more sway in the AP direction than did younger subjects. They also found that a relatively high amount of sway (3.17 mm) in the ML direction was indicative of a risk of falling and age-related disease. Baczkowicz et al assessed the relationship between postural stability, gait, and falls in elderly patients and found that the greater degree of sway a person had, the greater their incidence of falls.

Relatively few published reports have examined the relationship between the musculoskeletal system and balance.

Cervical vertigo, also called cervical dizziness, is thought to be due to abnormal afferent input from cervical proprioceptors in damaged cervical tissues, particularly cord impingement via conditions such as cervical stenosis. Although the mechanisms of cervical vertigo are not fully understood, musculoskeletal system treatments have shown some benefit. Hülse et al recommended manual medicine treatment whenever the symptoms of imbalance were concomitant with neck pain or cervical discomfort. Hülse and Grab et al suggested that the upper cervical vertebral connection, with direct muscle attachment and innervation to the occipital and temporal bones, may be a cause of cervical vertigo.

Cranial manipulation is also likely to affect vestibular function by means of the temporal bone structures housing the vestibular apparatus. In a French study, Caporossi used cranial manipulation to treat 92 patients with craniovertebral syndrome caused by motor vehicle accidents, and they showed generally improved postural stability (less sway).

Given the findings cited above, it is reasonable to hypothesize that osteopathic manipulative treatment (OMT) can help with vestibular problems and lead to improved balance. The proposed biomechanical mechanism of vestibular problems is based on the belief that the cranial nerves are trapped due to misalignment of the intracranial structures that have resulted from head trauma or severe postural imbalance. Entrapment of the vestibulocochlear nerve (cranial nerve VIII) and asymmetry between the temporal bones are specific neuroanatomic derangements thought to explain clinical observations that cranial manipulation restores balance and reduces vertigo and tinnitus. Anatomically, the vestibulocochlear nerve passes through the internal acoustic meatus of the temporal bone and over a vulnerable area of the jugular tubercle to the hindbrain. The vestibulocochlear nerve carries sound and position information from the semicircular canals, providing information about the head and body's dynamic equilibrium, and from the otoliths, providing information on static equilibrium. Vestibulocochlear nerve dysfunction can be caused by a number of factors, including dural membrane tension at the temporal bone and internal acoustic meatus or dysfunction of the petrojugular suture, which may result from even the slightest head trauma or prolonged postural strain on suboccipital and temporal musculature.

Trauma to the cranial base can also lead to balance disturbances by altering the nerve supply to and from the cerebellum (which controls the muscles maintaining balance). This nerve supply alteration may account for cervical vertigo and has been addressed in the treatment protocol used in the present study, which aimed to treat structures from the sacrum up to the head. In cranial osteopathic manipulative medicine, the sacrum and cranial bones are linked functionally. Therefore, applying OMT to the sacrum may affect cranial structures, as would applying OMT to all paravertebral and cervical musculature. For example, the sternocleidomastoid muscles and the trapezius muscles have attachments to the cranium, and...
somatic dysfunction in these muscles may therefore affect balance. Even the smaller muscles are important. For example, Hack et al.\textsuperscript{24} found that the rectus capitis posterior minor muscle has an attachment to the dura mater. Thus, the anatomic connections in vertebral column structures from the base of the skull to the sacrum may affect balance and postural control via connections to the cranial base or impingement on cervical proprioceptors.

The treatment protocol used in the present study is an attempt to clarify how the body’s musculoskeletal system affects its equilibrium control apparatus. Based on the proposed mechanisms of OMT action on vestibular balance control structures, it was hypothesized that after this protocol, elderly patients would show statistically significant improvement in empirical outcome measures used to quantify postural stability.

**Methods**

The present study was approved by the Institutional Review Board of the University of North Texas Health Science center at Fort Worth and was registered on ClinicalTrials.gov (number NCT01153412). Patient consent was obtained from each person.

**Patients**

Recruitment was accomplished through flyers posted on campus, university e-mail announcements, and from university clinics. Patients were compensated $20 per session. Healthy elderly patients (demographic details in Table 1) were enrolled in the study and separated into 2 groups: those receiving OMT and those not receiving OMT. Because of the limited time available for the OMT provider (D.L.) (April 2009 to August 2009), patients were not randomly assigned to the treatment groups; the first 20 patients to enroll, between April and June 2009, were in the OMT group, and the next 20, enrolled between June and October 2009, were in the control group. Some of the OMT patients could not start the treatments until August 2009.

Inclusion criteria included an age of at least 65 years and being generally free of any musculoskeletal complaints. Patients were excluded if they had a condition that could impair balance, such as an otoneurologic condition, orthostatic hypotension, cardiac arrhythmia, or a musculoskeletal or neurologic disease or disorder.

**Measurements**

Balance measures were obtained from a multiaxis force platform (AMTI model OR6-7-2000; Advanced Mechanical Technology, Watertown, Massachusetts). The force platform provides 6 outputs corresponding to 3 orthogonal force and 3 orthogonal moment axes acting on the platform’s top surface. Conventionally, the axes of the coordinate system are labeled $x$, $y$, and $z$, and the associated force and moment components are labeled $F_x$, $F_y$, and $F_z$ (force) and $M_x$, $M_y$, and $M_z$ (moment). The resolution of the measurement is 1 mm in both the $x$ and $y$ directions.

Patients were asked to stand on the force platform, with their arms hanging loosely by their sides, and to look at a landmark on the wall in front of them. They were barefoot and stood in a self-chosen foot position (not wider apart than the distance between their hip joints). The chosen foot stance was traced on paper to ensure that the patient maintained similar foot positioning for subsequent tests. Patients performed 3 balance tests: (1) with their eyes open, (2) with their eyes closed, and (3) with their arms extended 90 degrees in front of them and their eyes closed (modified Romberg test) (Figure 1). Each test was performed twice during each visit. For each test, 30 seconds of force platform data was collected, and the center of pressure (average of the pressure between the feet) was calculated. Outcome measures included AP and ML variance of the center of pressure values during the 30-second data collection.

At the first visit, initial balance tests were performed in both the OMT and control groups. All patients returned for subsequent balance tests after 1, 2, and 3 weeks. Weekly tests were performed at the same time of day as the first test. Patients in the OMT group had initial balance tests performed first, then received OMT, and then were immediately assessed again. Balance tests were assessed at the initial visit (ie, visit 1) and after 1, 2, and 3 weeks (ie, visits 2, 3, and 4).

**Intervention Protocol**

Patients in the OMT group received 4 weekly treatments, each 25 to 30 minutes, performed by the same practitioner (D.L.) to eliminate interexaminer variability. The first visit included a

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**Table 1. Effects of OMT on Balance in Elderly Patients: Demographic Information ($N=40$)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All Patients</th>
<th>OMT Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>12</td>
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</tr>
<tr>
<td>Women</td>
<td>28</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>35</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>African American</td>
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<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Age, y</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>65.89</td>
<td>65.85</td>
<td>65.89</td>
</tr>
<tr>
<td>Mean</td>
<td>72.1</td>
<td>72.8</td>
<td>71.5</td>
</tr>
</tbody>
</table>

* All data presented as No. unless otherwise indicated.

Abbreviation: OMT, osteopathic manipulative treatment.
musculoskeletal examination to screen out patients with any musculoskeletal disorder that affected balance, such as early Parkinson disease. No attempt was made to systematically record somatic dysfunction or obtain medical records that might document degenerative musculoskeletal disease. If somatic dysfunction was found during any visit, it was managed by using the treatment procedures of the protocol. The OMT protocol consisted of the following elements:

1. Soft-tissue and myofascial release25(p42a,44b) at T1 to L5 and sacral “rock”26(p775) (patient prone) (3-4 minutes)
2. Myofascial release in the shoulders and scapulae bilaterally26(p779) (patient lateral recumbent) (4-5 minutes)
3. Cervical spine myofascial,25(p40a) counterstrain,26(p758) muscle energy,26(p687) or soft-tissue25(p41d) techniques for release and correction (patient supine) (3-4 minutes)
4. Occipitoatlantal and condylar decompression25(p69d) (1-2 minutes)
5. Venous sinus technique27(p490-491) (5-6 minutes)
6. V-spread, frontal and parietal lifts, or both27(p488-489) (2-3 minutes)
7. CV4 technique26(p745) (3-4 minutes)
8. Recheck for other key tender points (2-3 minutes) and treat according to findings

Steps 4 through 7 had a cranial emphasis. More details on the OMT protocol may be obtained from the authors upon request.

For the control group, no musculoskeletal examination or intervention (eg, sham therapy) was provided.

Analysis
The average AP and ML positions of the center of pressure during the 30-second test were calculated from the force platform data. Average sway values for AP and ML were then calculated as the average displacement (or variance) of the average center of pressure. The variance (sway) values for both groups for visit 1 were used to determine whether the sway values in the 2 groups were comparable to those reported in the literature. The primary variables analyzed and used to determine differences between groups were the changes in AP sway and ML sway compared with visit 1.

Analysis of variance statistics were performed on the sway data using PC-SAS software (version 9.1.3; SAS Institute, Cary, North Carolina). Initially, univariate statistics were calculated on each measure for each condition (trial, test, and manipulation) to determine the frequency distributions and suitability of using analysis of variance. Unless explicitly stated otherwise, differences were considered statistically significant at \( P \leq 0.05 \).

Results
Of 79 patients who were screened, 34 were not interested in participating and 1 did not show up, leaving 44 patients to be enrolled in the study. Of the 44 patients who were enrolled, 2 were not able to complete half of the treatments. Another 2 were withdrawn by the principal investigator (D.L.), 1 because of signs of early-stage Parkinson’s disease and the other because of a sciatic nerve injury sustained at home in the middle of the treatment protocol.

Table 2 shows the raw AP and ML sway values in the OMT and control groups for the eyes-open and eyes-closed tests at visit 1 (before any OMT was performed). These data are similar to those reported by others,13,28 which indicates that our patient population was representative of a healthy elderly group.

Table 3 shows the changes in sway relative to the measurements at visit 1. Negative values indicate increased sway compared with the initial values measured at visit 1. Figure 2 shows the mean AP and ML changes from visit 1 for each test (ie, eyes open, eyes closed, and modified Romberg).

There was no statistically significant difference in ML sway in either group after the visit 2 or visit 3 testing period. After visit 4, there was a statistically significant decrease in AP sway for the eyes-open test (\( P = 0.001 \)).

Comment
The objective of the present pilot study was to evaluate the effect of an OMT protocol, with an emphasis on cranial manipulation, on vestibular balance control structures and postural stability in a healthy elderly population. The results show that
the OMT protocol employed in the present study slightly improved the postural stability of healthy elderly patients as measured by the force platform in the AP and ML directions. The significant reduction in AP sway after visit 4 is particularly important because of the greater likelihood of falls associated with AP instability. However, further study is required to determine whether the OMT-reduced sway observed in the present study and fewer falls in the elderly. Nevertheless, it is promising that the OMT group showed decreases in sway in both AP and ML directions, and therefore improved balance and posture, from visit 1 to visit 4. Improved postural stability in elderly patients may have a substantial impact on healthcare and the economy by reducing morbidity and mortality associated with falls in the elderly.

With results indicating that OMT has an effect on balance, other potential benefits for vestibulocochlear nerve function merit exploration, such as improvements in auditory processing and acuity. The OMT protocol is easy to teach and apply and is designed not only for clinical application but also for further research. Although certain procedures in the protocol may seem to have more direct effects on equilibrium control centers through the cranial bone structures, the whole protocol is necessary for further research. Although somatic dysfunction was not systematically recorded for patients in the present study, elements 1, 2, and 3 in the OMT protocol, based on prior clinical experience, were intended to deal with upper body and vertebral somatic dysfunction that could derange cranial base structures or impinge cervical proprioceptors via anatomic connections.

One limitation of the present study is that the patients were not randomly assigned into OMT and control groups. In addition, patients enrolled in the study were considered healthy individuals and were not necessarily screened for somatic dysfunction. Thus, because there was no sham or placebo group, it is not certain that the balance improvements were due to the OMT intervention. The study’s 4-week time frame—necessitated by patient availability, recruitment, and treatment resources—was both a strength and a weakness. Significant effects were obtained with only 4 OMT sessions. Could an even greater improvement have been achieved with longer duration and more OMT sessions? This is an open question. Further studies would be required to determine the long-term effects of OMT and how frequently patients would require physician follow-up.

### Conclusion

The OMT protocol used in the present study was designed to help determine how the musculoskeletal system may affect the body’s equilibrium control apparatus. Our objective was to evaluate the effect of an OMT protocol, which emphasized cranial manipulation, on vestibular balance control structures and postural stability in a healthy elderly population. We hypothesized that after this treatment protocol, elderly patients would show statistically significant reductions in sway. Our

<table>
<thead>
<tr>
<th>Visit</th>
<th>Eyes Open</th>
<th>Eyes Closed</th>
<th>Romberg Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OMT</td>
<td>Control</td>
<td>OMT</td>
</tr>
<tr>
<td>□ 2</td>
<td>-0.129</td>
<td>-0.397</td>
<td>-0.099</td>
</tr>
<tr>
<td>□ 3</td>
<td>-0.002</td>
<td>-0.719</td>
<td>0.055</td>
</tr>
<tr>
<td>□ 4</td>
<td>0.749*</td>
<td>-0.720</td>
<td>0.407</td>
</tr>
<tr>
<td>□ 2</td>
<td>-0.009</td>
<td>-0.401</td>
<td>0.127</td>
</tr>
<tr>
<td>□ 3</td>
<td>-0.225</td>
<td>-0.581</td>
<td>-0.011</td>
</tr>
<tr>
<td>□ 4</td>
<td>0.065</td>
<td>-0.584</td>
<td>0.034</td>
</tr>
</tbody>
</table>

* Positive values indicate decreased sway compared with the initial visit; negative values, increased sway.

**Abbreviation:** OMT, osteopathic manipulative treatment.

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**Table 2.** Effects of OMT on Balance in Elderly Patients: Mean Sway Values by Test* (N=40)

<table>
<thead>
<tr>
<th>Sway, mm</th>
<th>Eyes Open</th>
<th>Eyes Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMT</td>
<td>Control</td>
<td>OMT</td>
</tr>
<tr>
<td>Anteroposterior</td>
<td>4.91</td>
<td>3.77</td>
</tr>
<tr>
<td>Mediolateral</td>
<td>2.68</td>
<td>1.79</td>
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</table>

* The average center of pressure displacement for each test was used to determine anteroposterior and mediolateral sways. The averages for the control group are comparable to values found in the literature.

**Abbreviation:** OMT, osteopathic manipulative treatment.

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**Table 3.** Effects of OMT on Balance in Elderly Patients: Mean Changes in Sway Values by Test and Patient Visit* (N=40)

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**Figure 2.** Mean change from the initial visit in (A) anteroposterior (AP) sway values for the eyes-open test; (B) mediolateral (ML) sway values for the eyes-open test; (C) AP sway for the eyes-closed test; (D) ML sway for the eyes-closed test; (E) AP sway for the modified Romberg test; and (F) ML sway for the modified Romberg test. Positive values indicate decreased sway compared with the initial visit; negative values, increased sway. **Abbreviation:** OMT, osteopathic manipulative treatment.
results show that the OMT protocol slightly improved the postural stability of healthy elderly patients, as measured by the force platform in the AP and ML directions. As previously stated, the statistically significant reduction in AP sway is particularly important because of the greater likelihood of falls associated with AP instability. Further study is required to demonstrate the correlation between OMT-reduced sway observed in the present study and fewer falls in the elderly.

References