The Training of Older Patients to Improve Balance

by

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Ethical Standards:

Procedures followed in this study were in accordance with the Helsinki Declaration of 1975.

Statistical Evaluation:

Performed by Robin Carr, Ph.D., Langara College, Vancouver, B.C.
Abstract

The risk of accidental falls among elderly people is substantial, particularly among those who are within certain high-risk categories (e.g. reduced proprioception, muscle imbalances, and slow muscular response time). Early diagnosis of these individuals may provide opportunities for preventive measures within the chiropractic paradigm. This report outlines one approach to the assessment and management of these patients, emphasizing an attempted reduction in some of the risk factors. Assessment included the measurement of postural sway on a ‘centre of pressure locator.’ The treatment approach involved end-range spinal loading strategies. Results on the four subjects were promising. This was a pilot study with intent to provide information that could form the framework for a more comprehensive research project; therefore, the report includes an extensive literature review.
Introduction

Loss of balance and subsequent falls occur frequently among older people. While the causes appear complex and multi-faceted, early detection of those with high risk factors may provide opportunities for preventive measures within the chiropractic paradigm. This report outlines a pilot study for potential assessment and management of these patients.

Review of the Literature

Falls, Balance and Sway:

About 30% of the population aged 65 and older who are living at home fall each year and nearly one-half of all nursing home residents fall every year. Once an individual falls, there is a 60 - 70% chance that a subsequent fall will occur within the next six months. Approximately 15% of falls result in physical injury serious enough to warrant medical attention, and about 5 to 10% of falls yield serious injuries with potentially grave sequelae, including head trauma and bone fractures. The most serious fractures are generally those to the hip.
Falls have many causes,\textsuperscript{27,28} which can be roughly grouped into environmental factors, neurological diseases, and other acute illnesses.\textsuperscript{29} Many studies have assessed risk factors for falls among the elderly.\textsuperscript{27-43} Among those that have been suggested are decrements in balance,\textsuperscript{44-54} psychoactive drug use,\textsuperscript{55-61} evidence of stroke or brain injury,\textsuperscript{62-65} and cardiovascular abnormalities.\textsuperscript{66-67} Also implicated are Parkinsonism, blindness, drug-related hypotension, arthritis, a number of chronic disabilities, and social/psychological factors.\textsuperscript{30,31,38,40,68-71} Tideiksaar\textsuperscript{27} suggests the following classes of risk factors for falls: poor vision, cardiovascular problems, lower extremity dysfunction, gait and balance disorders, bladder dysfunction, cognitive dysfunction, and medications.

The risk of falls appears to be greater among women, the cognitively impaired, those who use hypnotics, tranquilizers, and diuretics\textsuperscript{70} and those with poor physical fitness.\textsuperscript{31,72} Risk factors that are potentially most relevant to the chiropractor include slowed motor responses, weakness of structural support, musculoskeletal limitations and deconditioning.\textsuperscript{31,40,73-77} Some investigators developed assessment tools to evaluate human balance performance, and attempted to detect differences between normal young and healthy older adults\textsuperscript{49,78,79}, active and inactive older adults\textsuperscript{80} and frequent fallers and non-fallers.\textsuperscript{45,81-83}
Falls occur when balance equilibrium is perturbed and upright posture is no longer maintained. Technically, a fall occurs when the body’s centre of mass passes outside its base of support. At this point, only an external force or a change in the base of support can prevent the fall from occurring. The risk of loss of balance thus increases as the centre of mass moves towards the edge of the base of support, as occurs to varying degrees during standing postural sway. Sway is a measure of the corrective mechanisms associated with the maintenance of an upright position.\(^{84-92}\)

Biomechanics force platforms provide a simple and reliable observer-independent method to assess sway, as they measure the movement of the centre of gravity (COG) in a horizontal plane. Technically, they indicate the centre of pressure (COP) acting through the feet, which reflects not only the ground reaction force necessary to oppose gravity, but also the moments of force that are produced to maintain standing posture. Although the COP is only identical to the vertical line from the COG when there is no sway, over the period of a testing trial the mean COP should be a good representation of the mean COG. (For a more complete discussion of this, see Winter\(^ {93}\) and Shimba\(^ {94}\)). Especially in
quiet standing positions, the movement of the COP approximates the movement of the centre of gravity in that horizontal plane.\textsuperscript{95}

It is generally accepted that smaller values of sway are indicative of better balance.\textsuperscript{57} The increased amount of sway seen in the elderly \textsuperscript{96-100} has been attributed to either biomechanical or central processing changes rather than diminished sensory or vestibular input.\textsuperscript{54} In older people, increased sway has been associated with an increased risk of falling.\textsuperscript{14, 66,74,83} (For example, Kirshen et al.\textsuperscript{66} showed a clear increase in sway among men with a history of falls as compared with those who had no such history, while Lord et al.\textsuperscript{83} showed greater lateral sway among older fallers.) Increased sway has been correlated with clinically validated measures of fall risk\textsuperscript{53, 101} and has even been shown to be predictive of fall incidents among ambulatory subjects\textsuperscript{11} and nursing home residents.\textsuperscript{52}

The amplitude of postural sway seems to be correlated with other kinematic measures and functional tests.\textsuperscript{46, 64} Antero-posterior sway tends to increase with age, and sway amplitude increases with challenges to vision and proprioception.\textsuperscript{102}

The force platforms used to measure sway are relatively simple to use, do not interfere with movement, and are not unpleasant or unsafe for
subjects. They are quite expensive however, and usually have to be embedded in concrete. For these reasons, they are generally found only in universities, hospitals, or other large institutions of research.

However, the assessment of body COG position (actually COP) and sway appear to have potentially important clinical applications in various health professions, in which the use of the criterion force platforms may not always be possible. As a result, many force-plate type systems for evaluating balance and sway have now become commercially available. Roland et al.\textsuperscript{92} reported on the use of a relatively simple and economical load-sensitive platform (the SwayWeigh) to measure lateral body sway in order to assess balance dysfunction. With it, the percentage of a patient’s total weight that was borne on the right foot enabled measurement of left-right weight distribution and lateral movement of the centre of gravity. Weerdt et al.\textsuperscript{65} had employed a similar platform to measure the rehabilitation of physiotherapy patients after cerebrovascular accidents. (In this study, measurements of postural sway were made using a centre of pressure locator (COPL) in lieu of a force platform - see details below).

Along with postural sway, Tideiksaar\textsuperscript{27} indicated that lower extremity dysfunction is another risk factor for falls. With aging, most people tend to
exercise less, the result being that tight muscles become tighter and inhibited ones become weaker. Afferent-efferent neuropathways used for proprioceptive balance and reactions are used less, as are central integrating processes.

Lack of exercise may also lead to discal creep, a progressive deformation of the discs under constant load. The sagittal disc wedging in turn leads to an increase of the kyphotic curve of the thoracic spine and a decrease in the lordotic curves of the lumbar and lower cervical spine. For some older people, degradation occurs to the point where even simple standing and walking activities can pose a threat to safety.

Rehabilitation of patients with these risk factors for falling should be both specific and time efficient. Treatment should be directed at re-balancing length and strength of the musculature. Hypertonic lower limb muscles should be lengthened, and inhibited muscle groups should be facilitated. Sensory-motor exercises that challenge the balance system should be emphasized. Spinal end range loading strategies should be used to reshape discs. After several weeks of treatment and supervision, many of these patients should be able to continue on a self-management basis.
Spinal End Range Loading Strategies:

Many elderly people have rounded shoulders and a forward head posture. Multi-segmental muscle length (from origin to insertion) is changed.\textsuperscript{107} It has been shown that the forward displacement of the cranium creates a greater vertical force on the lower cervical and upper thoracic spine.\textsuperscript{108} The upper thoracic spine has an exaggerated kyphosis, and both thoracic and lumbar spines have a limited range of extension. The normal ratios among flexion, extension and rotation are changed.\textsuperscript{109} The instantaneous axes of rotation of these vertebral segments are distorted and therefore become a source of nociception. For example, joint mechano-receptors become attenuated to abnormal positions, giving the person a feeling of normalcy. Kinetic chains and agonist, synergist and antagonist muscle actions change. Faulty movement patterns result.\textsuperscript{110} Events like this may cause one’s balance to be worsened.

The McKenzie approach\textsuperscript{111-113} postulates that there is an ideal posture that people should be able to attain, and that the capacity to maintain this ideal posture can be lost through a lack of self-awareness. Sedentary lifestyles frequently produce prolonged postures in spinal flexed positions. Discal creep occurs and eventually an internal disc disruption takes place.\textsuperscript{114,115}
At this point, tissue damage and inflammation may occur, producing scarring and possibly contractures within the more elastic host tissue (annular fibers). This internal disc derangement may be a source of nociception as pain and disturbed intersegmental movement.\textsuperscript{117} It may also be a source of autonomic afferent stimulation\textsuperscript{118,119} from the disc to balance centres in the CNS. These afferent fibers would probably exist as free nerve endings and their stimulation alone may affect the higher centres.\textsuperscript{118,119,120,121}

The McKenzie approach promotes restoration of good posture, improvement of the morphology of the discs and an increase in the intersegmental spinal movement that may previously have been restricted due to the discs. By loading the discs at end range in the restricted movement plane, their internal architecture can be changed or reduced to a more normal arrangement. This reduction results in an increase of motion in the restricted plane, a decrease in pain and possibly a change in postural sway. These loading strategies may be effective after one application, or in the case of scar tissue involvement they may require up to six weeks.
Methods

Patients:
Subjects consisted of one male and three females: patient M (female, 77 years); patient N (female, 82 years), patient O (female, 80 years); and patient R (male, 70 years).

Patient N had both hips replaced. Patient R had his forefoot amputated in 1997 due to atherosclerosis, and had poor vision and a lack of depth perception that were also due to this condition.
Assessments

Dependent variables included the following:

1. **EAM-T Distance**
   This is the horizontal distance between the external auditory meatus and the apex of the thoracic curve with the subject standing comfortably and relaxed.

2. **Extension**
   This was the range of motion available in the thoracic and lumbar spines during extension.

3. **Postural Sway**
   This was measured on a ‘centre of pressure locator’ (COPL) that had previously been found to be precise and reliable in measuring postural sway\(^{122}\), with twelve trials spread equally over two days (am and pm), for both the pre-test and post-test measurements.
**Treatment**

After the two days of pre-testing, the subjects were treated over a three to four week period. All four subjects were treated the same way for this study, using only spinal loading strategies.

McKenzie treatment protocols included those for posterior derangement and extension dysfunction of the lower cervical, thoracic and lumbar spines.\(^{111}\) This included repeated, loaded end range extension of these areas as well as traction and retraction of the cervical spine.\(^{112}\) Education and home exercises were also included.\(^{113}\)

At the conclusion of the treatment period, two days of post-testing occurred following to the format of the pre-tests.
Analysis:

Postural sway results were analyzed using a one-way repeated measures analysis of variance (ANOVA), with alpha set at 0.05.

Results

The results for each individual are presented separately, since each patient was unique and may have responded to the treatment differently from the others. Also, the small number of subjects and lack of random sampling negate the external validity of any group findings.

The repeated measurements of postural sway on the COGL (12 on the pre-test and 12 on the post-test) allow for significance testing of the changes for each individual. One-tailed T-tests for repeated measures were used to assess significance with a 0.05 alpha level.
Patient M (Treatments: April 30, May 3, 5, 10, 13, 19, 26, 28.)

Patient M (female, 77 years) was somewhat inconsistent in showing up for her treatments, but she did report subjectively assessed improvements in her balance. This was objectively supported by the data, which describe significant reductions in both A-P and L-R sway, shown in figures 1 and 2 below. Since Patient M’s sway was quite large on the pre-tests, it could be argued that there was more room for improvement in her test results.
Figure 1: Patient M shows significant ($p < 0.01$) reduction in A-P sway.
Figure 2: Patient M shows significant ($p < 0.01$) reduction in L-R sway.
Table 1: Summary of other results for Patient M. The EAM-T distance was reduced on the post-test, and there was a slight increase observed in lumbar extension.
Patient N (Treatments: April 28, 29, May 1, 3, 5, 8, 11, 13, 17, 20, 25, 26.)

Patient N (female, 82 years) complained after her ninth session that her left hip had become quite stiff and sore. At that time she walked with a “duck waddling” motion characteristic of a capsular pattern.
Figure 3: Patient N shows significant ($p < 0.05$) reduction in A-P sway.
Figure 4: Patient N shows non-significant (p > 0.05) reduction in L-R sway.

(Note: If the 9th trial in the pre-test is dismissed as an outlier due to an extreme movement or momentary loss of equilibrium, the difference between pre- and post-test results becomes significant at the 0.05 level.)
<table>
<thead>
<tr>
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<th>Pre-Test</th>
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<tr>
<td>EAM-T distance</td>
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<td>25</td>
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<tr>
<td>Lumbar extension</td>
<td>7</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 2: Summary of other results for Patient N.
Patient O (Treatments: April 28, 30, May 3, 5, 7, 11, 14, 19, 26.)

Patient O (female, 80 years) was the spryest of the group, but in the final stages of testing she came down with an acute case of diverticulitis.

Despite this, marked reductions were shown in her sway.
Figure 5: Patient O shows significant ($p < 0.001$) reduction in A-P sway.
Figure 6: Patient O shows significant (p < 0.001) reduction in L-R sway.
### Table 3: Summary of other results for Patient O.

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<td>EAM-T distance</td>
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<tr>
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<td>15</td>
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<td>Lumbar extension</td>
<td>10</td>
<td>18</td>
</tr>
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</table>
Patient R (Treatments: April 30, May 5, 7, 10.)

Patient R (male, 70 years), who had his right foot amputated and who complained of poor vision and a lack of depth perception, said he was doing really well until several hours after the fifth session. Upon bending down to tie his shoelace his vision deteriorated almost instantly. Although his vision did recover over the next few days, he was then stricken with a bad flu. He only completed four treatment sessions and three of the post-test sway sessions.
Figure 7: Patient R shows significant ($p < 0.001$) reduction in A-P sway.
Figure 8: Patient R shows significant (p < 0.05) reduction in L-R sway.
<table>
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<tr>
<th>Patient R</th>
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Table 4: Summary of other results for Patient R.
Discussion

It is difficult to conduct controlled clinical studies when working with older people who may be in poor general health. Intervening factors, such as sudden illness onset or other acute conditions, can impede the controls that are desired in scientific studies.

Nonetheless, significant reductions in sway were found for these subjects, as well as suggestive reductions in EAM-T distance and gains in thoracic and lumbar extension. It appears that this treatment protocol shows promise for reducing sway and thereby the risk of falls.

Furthermore, if autonomic afferents do exist in the disc, it would seem logical that their presence would be greatest where the largest sympathetic innervation is found. The upper thoracic spinal cord supplies the sympathetic nerves to the heart. It would seem reasonable to hypothesize that the upper thoracic discs also receive a supply. Perhaps the marked upper thoracic kyphosis and consequent internal disc disruptions older people often display is a key to their increased postural sway.
McKenzie has shown repeatedly the phenomenon of centralization.\(^\text{123}\) (i.e. the proximal shift in pain patterns after or during loading strategies). Pain sensation may largely be initiated by free nerve endings and, in this case, free nerve endings in the disc. If these free nerve endings are affected by an internal disc disruption, what about others; for example, autonomic afferents? These findings imply that a useful treatment protocol was followed, and that more extensive clinical studies should be done to attempt to support these findings.

References


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