The Role of the Cervical Spine in Balance and Risk of Falling in the Elderly

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ABSTRACT: Falls in the aged are a significant cause of injury and decreased quality of life. This paper reviews the common causes of falls and some possible interventions. A number of validated clinical measures to assess balance and risk of falling are discussed. It is further postulated that the cervical spine may affect balance and risk of falling due to its role in postural control.

INDEX TERMS: (MeSH); CHIROPRACTIC; EQUILIBRIUM; ACCIDENTAL FALLS; AGED; CERVICAL VERTEBRAE; NECK.

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INTRODUCTION

In both the elderly and rehabilitation populations, the maintenance and/or restoration of balance (and mobility) are essential. A decline in the ability to maintain balance has been identified as a significant risk factor for falls.[1] Maintenance of balance is determined by many factors, such as visual cues, inner ear mechanisms and mobility. There is growing evidence that an important relationship exists between the functions of the spine—in particular the cervical region—and the complex neurology involving the senses of vision, balance and coordination.[2,3]

Over the past century there has been a trend for an increasingly aging population. It is estimated that by early 2000, over 20% people were over 60 years of age. According to the Australian Bureau of Statistics (ABS), in the twenty years from 1980 to 2000, the number of persons aged 65 years and over has increased by 67%, nearing 2.4 million in total, and in the 85 years and over group there has been an increase of 156% to just over 250,000 in total.[4,5]

Older people have different risk factors for ill health and injury than the younger population. Two major causes of injury and impairment in the elderly are falls and reduced physical function. Age-related changes in the neural, sensory and musculoskeletal systems can lead to impairments in postural control systems and balance, resulting in increased risk of falls and reduced ability to move around safely.[6] Injuries resulting from falls, particularly in the aged, can result in a loss of independence, psychological stress, a general decrease in quality of life and spiralling costs in the health care system.

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The problem of falls among older Australians is a major health issue. In 1994, it has been estimated that the health costs associated with falls-related hospitalisations exceeded AUD$4,500 million and are growing.[7]

Falls that do not cause injury can lead to a downward spiral of fear that leads to inactivity and loss of independence in normal activities. Thus anything that can be demonstrated to improve balance and reduce falls is of great benefit to the individual and to society as a whole *via* improved quality of life and reduced healthcare and rehabilitation costs.

The relationship of the cervical spine to the to risk of falling has not been investigated. A pilot study is currently examining the effect of neck pain and dysfunction on balance and clinical functional indicators of risk of falls, particularly in the aged.

DEFINITIONS

- **Balance** refers to the postural component of human movement, orientation and alignment of body segments that is required to maintain equilibrium during stationary tasks.[8]
- **A fall**: A formal definition used in most clinical studies is that a fall is a non-syncopal event not attributable to sustaining a violent blow, loss of consciousness, stroke, or epileptic seizure.[9] It has also been defined as a sudden, unintentional change in position causing an individual to land at a lower level, on an object, the floor, or the ground, other than as a consequence of sudden onset of paralysis, epileptic seizure, or overwhelming external force.[10]
- **A faller** is someone having 2 or more falls within the last 6 months.[11]

BALANCE AND THE CERVICAL SPINE

Dizziness and subjective balance disturbances are frequent complaints in cervical pain syndromes of different origins, and the importance of neck proprioceptors for maintaining balance is gaining increased interest.

It can be postulated that the presence of dysfunction in the neck may lead to changes in postural control mechanisms that may cause a decrease in the ability to maintain balance. Impairment of the mechanoreceptors from structural changes such as spondylosis may result in balance loss, especially related to head rotation.[12]

A study of cervicocephalic kinaesthesia (the ability to relocate accurately the head on the trunk after an active movement in the horizontal plane) found that sensibility was significantly poorer in patients with chronic cervical neck pain than in healthy subjects, suggesting an alteration in neck proprioception.[13]

Rzewnicki,[14] in a study of 146 patients with degenerative changes in the cervical spine, found that 74% had balance disturbances.

Karlberg *et al.*[15] studied 107 patients with cervicobrachial pain syndrome of more than 3 months duration. They found both a group of patients with MRI-verified cervical root compression (CRC group, n=89) and a group with normal MRI of the cervical region (non CRC group, n=18) manifested significantly poorer postural control than sex- and age-matched controls (n=20). They concluded that disorders of the neck should be considered when assessing patients complaining of dizziness or vertigo.

A recent study has shown that that neck nociceptive input can induce changes in the ability to perceive verticality,[16] indicating possible changes in proprioceptive ability and balance.

Under normal circumstances, a person balances by integrating sensory information from the visual, vestibular, and somatosensory systems. This information is used to select appropriate motor responses for the maintenance of postural equilibrium. If the information from one system is deficient or altered, the information from the other systems should compensate and allow the individual to remain in static postural equilibrium. A study of athletes sustaining mild head injuries has reported them to exhibit sensory interaction problems, whereby they are unable to ignore altered sensory information, resulting in the selection of improper motor responses for up to 3 days post-injury.[17]

Schieppati *et al.*[18] demonstrated that neck muscle fatigue could alter body balance control through a mechanism connected to fatigue-induced afferent inflow. They argued that neck muscle fatigue affects mechanisms of postural control by producing abnormal sensory input to the CNS and a lasting sense of instability. An earlier study by the same author[19] found that correct perception of sway was shown to be unaffected by either peripheral neuropathy or Parkinsonism. They thus postulated that the afferent discharge from the neck might play a dominant role in calibrating all other sensory inputs; an anomalous inflow and the consequent incongruent central integration of it might be one of the factors contributing to dizziness.

Dizziness and/or unsteadiness are common symptoms of chronic whiplash-associated disorders. Treleaven *et al.*[20] conducted a study that aimed to report the characteristics of these symptoms and determine whether there was any relationship to cervical joint position error (the accuracy to return to the natural head posture following extension and rotation). The results indicated that subjects with whiplash-associated disorders had significantly greater joint position errors than control subjects. Within the whiplash group, those with dizziness had greater joint position errors than those without dizziness following rotation. Characteristics of the dizziness were consistent for those reported for a cervical cause, but no characteristics could predict the magnitude of joint position error. Cervical mechanoreceptor dysfunction is a likely cause of dizziness in whiplash-associated disorders.

Kogler *et al.*[21] also found that subjects with neck problems, such as whiplash injuries, often complain of disturbed equilibrium, and in some instances, provocation of the neck position can elicit such problems. They concluded that the postural control system is significantly challenged in the head extended backwards position in both normal subjects and patients with previous whiplash injury and persistent neck problems. The patient group differed statistically from all groups of normal subjects. This suggests that neck problems impair postural control, and that the head extended position is a more challenging task for the postural system to adapt to. Whether this is due to utricular malpositioning, central integrative functions or cervical proprioceptive afferents was not within the scope of their study to answer.

An interesting German study[22] establishes a link between vertebral subluxation and vertigo. In the study of 67 patients in which cervical imbalance was suspected, the vestibulospinal reactions were monitored directly before and after manual therapy of the cervical spine. A highly significant improvement of pathological vestibulospinal reactions was seen after chiropractic manipulation of the spine. These results show that a functional disorder of the cervical vertebrae influences the vestibulospinal reactions. The study concluded that "the pathological deficit of the vestibulospinal reactions is not solely a phenomenon of peripheral labyrinth malfunction, failure in the brainstem or in the area of the cerebellum ("brain stem staggering"), but can also be viewed (nearly ?) regularly by cervical disturbance of the equilibrium. The results of the treatment can be observed within a few hours."

CONSEQUENCES AND RISK FACTORS OF FALLS

The most common injuries arising from falls are fractures, (particularly of the femur neck) and soft tissue injuries, with 5% of falls leading to fractures and 10% to soft tissue injury.[23] Death due to a fall is the sixth leading cause of death in older people, with 75% of persons who die from a fall being over 65.[24]

Trips and slips most commonly cause falls in the elderly.[25] These are sometimes referred to as Base of Support (BOS) falls involving a failure to get the foot or feet back under the body's Centre of Mass (COM).

Risk factors for falls can be extrinsic (environmental) or intrinsic (related to the individual). It has been estimated that for 36% of falls the cause is unknown; 34% are due to intrinsic factors, and 11% have an extrinsic cause.[26] Among the commonly recognised intrinsic factors are decreased balance and mobility. Other intrinsic factors identified are disorders in strength, gait and vision. A number of medical conditions such as Parkinson's, vertigo, stroke and

incontinence cause instability. Some medications such as anti-psychotics, antidepressants, antihypertensives, sedatives and diuretics[9] have also be been related to increased falls.

CLINICAL MEASURES OF BALANCE AND RISK OF FALLING

There are a number of reliable and valid clinical tests that can be used by the practitioner to assess the balance of a patient in a clinical setting.

Functional Performance

- **Berg Balance Scale.**[27-29] Rate performance from 0 (cannot function) to 4 (normal performance) on 14 different tasks, including ability to sit, stand, reach, lean over, turn and look over shoulder, turn in a complete circle and step. It has been shown to have excellent inter-rater reliability and good validity in assessing balance and as a predictor of risk of falling.
- **Functional Reach.**[30,31] Measures the furthest one can reach beyond arm's length in the standing position while maintaining a fixed base of support. Studies have indicated good inter-examiner reliability and validity for this test.
- **Timed Up & Go Test.**[32] Subjects are timed to stand from an armchair, walk to a line 3 metres away, turn, return to chair and sit down again.

Disability

Falls Efficacy Scale (FES). A 10-item questionnaire assessing confidence in performing essential, non-hazardous activities of daily life.[33] This has been modified by Hill[34] to include extra items that cover outdoor activities.

Falls History

Retrospective and /or prospective history of the number of falls experienced in a 6- or 12-month period.

PREDICTING RISK OF FALLING

According to Hill,[34] in order to identify older people prone to falls at an early stage, preferably before any falls have occurred, detailed clinical evaluation of balance performance, activity levels and fear of falling need to be conducted. The clinical measures described above provide the practitioner with simple tests that can be applied effectively in the clinical setting to assess the risk of falling in older patients.

Whitney *et al.*[35] reviewed the reliability, validity and predictive validity of clinical balance measures commonly used for older people, including those described in this paper. They found that all reviewed instruments had adequate inter-rater reliability, with the Berg scale and the functional reach test also having established predictive validity. On the Berg scale, a score of <45 (maximum 56) was shown to be predictive of multiple falls in older adults, however it is more specific in identifying persons who do not fall.[36] A Functional Reach score of less than or equal to 15 cm has been shown to be predictive of falls in elderly males.[37] Both of these tests are reliable and valid, have actual cut-off scores predictive of falls, and may be helpful in setting objective goals for patients. The Timed Up & Go Test is more sensitive to change and more suitable to determine change over time or the outcome of an intervention program.[35]

INTERVENTIONS AND PREVENTION PROGRAMS

A number of interventions to decrease the number and the risk of falls in the elderly have been studied. Common interventions studied include exercise, home hazard improvement and educational sessions.

Gardner *et al.*[38] assessed the effectiveness of exercise programs in preventing falls and/or lowering the risk of falls and fall-related injuries in older people. They looked at clinical trials in which participants were 60 years or over and community-dwelling rather than institutionalised. The exercises included exercise classes, balance training, endurance training and T'ai Chi. Their conclusion was that exercise is effective in lowering the risk of falls in selected groups but must be regular and sustainable.

Day *et al.*[39] tested the effectiveness of three interventions on 1029 Australian subjects in preventing falls in people 70 years or over who were living at home. They found that a weekly exercise program focusing on balance supplemented by home exercises reduced the number of falls. The addition of home hazard management or impaired vision management or both further reduced falls.

A trial examining the effectiveness of education and awareness, exercise sessions and home safety advice and medical assessment to improve health indicated that these low-cost programs can reduce the incidence of slips, trips and falls in healthy older people.[40]

A systematic literature review conducted by Feder *et al.*[41] according to Cochrane criteria concluded that, for high risk people, assessment after falls with development of individual exercise and education programs decreases falls, and multifaceted interventions are more effective.

ROLE OF CHIROPRACTIC

The cervical spine, as discussed earlier, has a significant role in postural control, and thus is likely to affect risk of falling. A pilot study is currently being conducted by the authors to see if there is a difference in balance, as measured by the clinical measures discussed above, between people over 60 years with neck pain and those without neck pain.

Also, many recognised causes of instability such as vertigo, joint disorders and some peripheral neuropathies can be successfully managed by chiropractic care.[42]

CONCLUSION

Falls in the elderly are a significant cause of injury and loss of confidence in performing daily activities. Several clinical tests for assessing balance and risk of falling are available that are simple and can be performed in a few minutes. The identification of patients at risk of falling can lead to recommendation of appropriate care. A number of interventions have been shown to be effective in reducing falls. These include selected exercise programs, home hazard improvement and education plus addressing medical problems such as visual impairment.

The role of chiropractic care in decreasing risk of falling has not been investigated, however, given the role of the cervical spine in postural control, it can be postulated that neck pain and/or dysfunction could be associated with decreased balance and increased risk of falling.

REFERENCES

1. Tinetti ME, Williams T, Mayewski R. Fall risk index for the elderly based on number of chronic disabilities. Am J Med. 1986; 80:429-34.
2. McPartland JM, Brodeur RR, Hallgren RC. Chronic neck pain, standing balance, and suboccipital muscle atrophy—a pilot study. J Manipulative Physiol Ther 1997; 20:24-9.
3. Terrett AG, Gorman RF. The eye, cervical spine and manipulative therapy: a review of the literature. Chiropr Tech 1995; 7(2):43-54.
4. Australian Bureau of Statistics. Population by age and sex. ABS Cat. No. 3201.0, 2000; p. 6.
5. The Australian Bureau of Statistics. Disability and disabling conditions. ABS Cat No. 4433.0 1997; p.3.
6. Maki BE, McIlroy WE. Postural control in the older adult. Clin Geriatr Med 1996; 12:635-58.
7. Hill K, Schwartz J, Flicker L, Carroll S. Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy. Aust NZ J Public Health 1999; 23(1):41-48.
8. Ragnarsdottir M The concept of balance. Physiotherapy 1991; 82: 368-75.
9. Leipzig RM, Cumming RG, Tinetti ME, Drugs and falls in older people: a systematic review and meta-analysis: i. psychotropic drugs. J Am Geriatric Soc 1999; 47(1):30-39.
10. Tinetti ME, Baker DI, Dutcher J, Vincent JE, Rozett RT. Reducing the risk of falls among older adults in the community. Berkeley, CA: Peaceable Kingdom Press, 1997.
11. Shumway-Cook A, Baldwin M, Polissar NL, Gruber W. Predicting the probability for falls in community-dwelling older adults. Phys Ther 1997; 77:812-9.
12. Bowers L. Clinical assessment of geriatric patients: unique challenges. Top Clin Chiropr 1996: 3(2); 10-22.
13. Revel M, Minguet M, Gergoy P, Vaillant J, Manual Jl. Changes in cervicocephalic kinesthesia after proprioceptive rehabilitation program in patients with neck pain: a randomised controlled trial. Arch Phys Med Rehabil 1994; 75:895-9.
14. Rzewnicki I. The examination of vestibular system in patients with degenerative changes of the cervical spine. Otolaryngol Polska 1995; 49(4);332-8.
15. Karlberg M, Persson L, Magnusson M. Reduced postural control in patients with chronic cervicobrachial pain syndrome. Gait Posture 1995; 3(4):241-9.
16. Grod JP, Diakow PR. Effect of neck pain on verticality perception: a cohort study. Arch Phys Med Rehabil 2002; 83:412-5.
17. Riemann BL, Guskiewicz KM. Effects of mild head injury on postural stability as measured through clinical balance testing. J Athletic Training 2000; 35(1):19-25.
18. Schieppati M, Nardone A, Schmid M. Neck muscle fatigue affects postural control in man. Neuroscience 2003; 121(2):277-85.
19. Schieppati M, Tacchini E, Nardone A., Tarantola J, Corna S. Subjective perception of body sway. J Neurol Neurosurg Psychiatr 1999; 66: 313-22.
20. Treleaven J, Jull G, Sterling M. Dizziness and unsteadiness following whiplash injury: characteristic features and relationship with cervical joint position error. J Rehabil Med. 2003; 35(1):36-43.
21. Kogler A, Lindfors J, Odkvist LM, Ledin T. Postural stability using different neck positions in normal subjects and patients with neck trauma. Acta Otolaryngol 2000; 120(2):151-5.
22. Hulse M, Holzl M. Vestibulospinal reactions in cervicogenic disequilibrium. HNO 2000; 48(4):295-301.
23. Tibbitts M. Patients who fall: how to predict and prevent injuries. Geriatrics 1996; 51(9):24-31.
24. Abrams W, Beer M, Berkow R. The Merck manual of geriatrics. 2nd ed. Whitehouse Station, NJ: Merck Research Laboratories, 1995: 69.
25. Toffler AK, Maki BE, Holliday PJ. Are activity-based assessments of balance and gait in the elderly predictive of risk of falling and or type of fall. J Am Geriatric Soc 1993; 41:479-87.
26. Rietz S, Hagel K. Falls incurred by the elderly resulting in injury: pathogenesis and rehabilitation. Rehabilitation 1999; 38(1); 16-19.
27. Berg KO, Wood-Dauphine SL, Willams JI, Gayton D. Measuring balance in the elderly: preliminary development of an instrument. Physiotherapy Canada 1989; 41:304-11.
28. Berg KO, Wood-Dauphine SL, Willams JI,Maki BE. Measuring balance in the elderly: validation of an instrument. Can J Public Health 1992; 83:S1-S7.
29. Berg KO, Maki BE, Williams JI, Holliday PJ, Wood-Dauphine SL. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil 1992; 73:1073-80.
30. Duncan PW, Weiner DK, Chandler JM, Studenski SA. Functional reach: a new clinical measure of balance. J Gerontol 1990; 45(6): M192-7.
31. Giorgetti MM, Harris BA, Jette A. Reliability of clinical balance outcome measures in the elderly. Physiother Res Int 1998; 3(4):274-83.
32. Podsiadlo D, Richardson S. The timed "up and go" test: a test of functional mobility for frail elderly persons. J Am Geriatr Soc 1991; 39:142-8.
33. Tinetti ME, Richmond D, Powell L. Falls efficacy as a measure of fear of falling. J Gerontol 1990; 45:P239-43.
34. Hill KD, Schwartz JA, Kalogeropoulos AJ, Gibson SJ. Fear of falling revisited. Arch Phys Med Rehabil 1996; 77:1025-9.
35. Whitney SL, Poole JL, Cass SP. A review of balance instruments for older people. Am J Occup Ther 1998;52:666-71.
36. Thorbahn LDB, Newton RA. Use of the Berg balance test to predict falls in elderly persons. Phys Ther 1996; 76:576-83.
37. Duncan PW, Studenski S, Chandler J, Prescott B. Functional reach: predictive validity in a sample of elderly male veterans. J Gerontol 1992; 47:M93-8.
38. Gardner MM, Robertson MC, Campbell AJ. Exercise in preventing falls and fall-related injuries in older people: a review of randomised controlled trials. Br J Sports Med 2000; 34(1):7-17.
39. Day L, Fildes B, Gordon I, Fitzharris, Flamer H, Lord S. Randomised factorial trial of falls prevention among older people living in their own homes. Br Med J 2002; 325:128-33.
40. Steinberg M, Cartwright C, Peel N, Williams G. A sustainable programme to prevent falls and near falls in community dwelling older people: results of a randomised trial. J Epidemiol Community Health 2000; 54:227-32.
41. Feder G, Cryer C, Donovan S, Carter Y. Guidelines for the prevention of falls in people over 65. Br Med J 2000; 321(7267):1007-1011.
42. Gleberzon BJ. Instability and falls. In: Gleberzon BJ (ed). Chiropractic care of the older patient. Boston: Butterworth-Heinmann, 2001.