Department of Veterans Affairs

Journal of Rehabilitation Research and Development Vol. 33 No. 1, February 1996
Pages 1–5

Head extension and age-dependent posturographic instability in normal subjects

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Abstract—We have investigated the role of head extension in posturographic testing of normal subjects. We especially wished to determine the number of falls that occurred in the "normal" elderly so as to distinguish them from elderly patients with abnormal neurologic and vestibular patterns.

We tested 144 normal subjects ages 22 to 85, the majority older than 60 years, with the NeuroCom Equitest sensory posturography protocol: first with their heads erect and then with their heads extended 55°.

None of our subjects younger than age 59 experienced a fall during sensory posturography tests with their heads erect. However, 35 of the 101 older subjects exhibited a total of 79 falls during these same tests. When the tests were repeated with the head extended 55°, the number of falls for the whole group increased from 79 to 171. Where only 24% of all the subjects fell with head erect, 52% fell with head extended. The increase was especially notable among the elderly.

Head extension increases the difficulty of performing certain posturography tests and has been useful in uncovering compensated deficits in equilibrium in young and middle-aged patients. However, because head extension significantly increases falls among normal elderly subjects, this does not seem to be an effective tool to determine abnormality in this age group.

Key words: *balance disorders, elderly, equilibrium, falls, head position, postural control.*

This material is based upon work supported by the Rehabilitation Research and Development Service, Department of Veterans Affairs, Washington, DC.
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INTRODUCTION

Various types of posturographic tests have been used to describe the postural stability of different groups of patients and their performance compared to normal subjects (1–7). Dynamic posturography is a significant new procedure to test for the differential diagnosis of disequilibrium and to investigate mechanisms of control of normal equilibrium.

In many of the investigations of different groups using posturographic methods, it appeared that many patients with diagnosed balance abnormalities were producing normal test values. We have investigated the role of head extension during dynamic posturography as a tool for increasing the sensitivity of the NeuroCom Equitest procedure for detecting abnormalities (8–12).

We have found, in the latter work, that head extension increases postural sway in normal, younger subjects in the more difficult tests that use platform sway referencing. Also, it induces the loss of balance and falls (defined as a loss of balance, step correction, or foot movement, or grabbing of the platform structure for support) in patients with symptoms of disequilibrium or in some elderly subjects that had normal test values when their heads were erect during testing. If falls during posturography testing are going to be used to help determine postural abnormality (11,12), it is necessary to better determine how often normal subjects lose their balance during head extension. It is commonly held that disequilibrium increases with age (5,13). We wished to add to our previous data in which we examined the effects of head position and age on fall incidence in studies of dynamic posturography (9,10).

METHODS

The NeuroCom Equitest dynamic posturography device and procedures were used on all subjects. The same person administered the motor control tests, followed by the sensory organization tests. This study will be limited to results from the sensory tests.

In the sensory tests, the protocol measures postural sway in six defined test conditions using pressure sensitive strain gauges located in each quadrant of a force platform. The test subject stands on the platform and the device provides center of mass sway position over 20-sec trials. The contributions of vision, ankle proprioception, and the vestibular system are assayed.

In sensory test condition 1, the subject stands with eyes open. In condition 2, the eyes are closed. These two tests are similar to the standard neurological Romberg tests. In test condition 3, the subject's eyes are open but the visual surround that faces the subject is sway-referenced, that is, it moves whenever there is anterior-posterior body sway. Thus, instead of the visual scene getting closer or farther away when the subject sways, the scene sways in concert with the body. This makes vision less useful as an orientation reference. In test condition 4, the eyes are open and the support surface (platform) is sway-referenced. The platform moves proportionally to the anterior-posterior body sway angle. This distorts the proprioception from the ankles and promotes a conflict between visual, vestibular, and proprioceptive information. In test condition 5, the eyes are closed and the support surface is sway-referenced. In this condition, the visual information is absent and the proprioceptive information is distorted or inaccurate. The subject must depend on the vestibular sense for balance. In test condition 6, the eyes are open and both the visual surround and the platform are sway-referenced. The visual and proprioceptive data are now inaccurate, providing a conflict with the normal vestibular input.

In the sensory condition tests, each subject performed either 2 or 3 consecutive trials of test conditions 1–4, then 3 trials each of test conditions 5 and 6. After a 5-min rest, the subject repeated sensory tests 4–6 with his/her head extended (tilted back) 55°.

A simple inclinometer that was described previously (8) was used to position the head at 55°. This is the approximate value used by Brandt et al. (14) to demonstrate the effect of head extension in normal subjects. The visual surround extended over the subject's head so he is still provided with conflicting visual information in test conditions 4 and 6 with head extension. Five to 10° variations in head extension occur during testing in some subjects, especially when they are having difficulty keeping their balance. Once the head is extended to the correct position, most subjects seem to have little trouble keeping the position for 20 sec. Once they have gone through one test, they usually can reset their head position within 5° for the remaining tests. An occasional subject, usually elderly, has a stiff neck and cannot extend more than 35–40°. We did not include these subjects in this study. Neither our subjects nor those of Brandt et al. showed clinical signs of ischemia in the brain stem or cerebellum during head extension. However, they often commented that head extension seemed to make it more difficult to maintain their equilibrium.

We counted only the falls in sensory test conditions 5 and 6 during the three, 20-sec tests. Falls occurred in all portions of the 20-sec interval. If any of these subjects were involved in studies that tested them more than once, we only used the data from the first test.

The 144 subjects were chosen so there were at least 10 subjects in each decade from 20 to 59 years. Because of the importance of the results from the elderly, we tested 101 subjects aged 60 to 85. All of the 144 subjects were considered normal in that they gave no history of vertigo or disequilibrium. The subjects above 60 years all considered themselves physically fit and had no serious musculo-skeletal deficits. The protocol was approved by the Human Investigation Committee of Emory University. The subjects signed an informed consent agreement.

RESULTS

None of our subjects up to the age of 58 lost their balance or had a posturographic fall in test conditions 5 and 6 with their heads erect (**Figure 1**). However, 35 subjects, ages 59 through 85, exhibited 79 falls with head erect. These 79 falls occurred in 606 test trials of sensory tests 5 and 6. Thus, there were falls in 13 percent of trials in the elderly subjects. As an example, inspection of **Figure 1** shows that one 72 year old fell on each of the six trials and one 85 year old had no falls

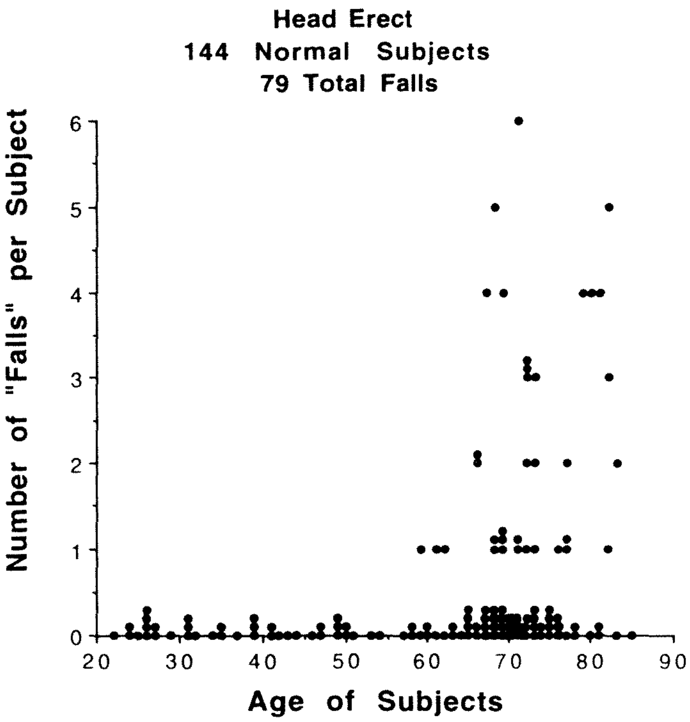

Figure 1.
A display of the number of posturographic falls for each subject as related to the subject's age. The tests were performed with the head erect.

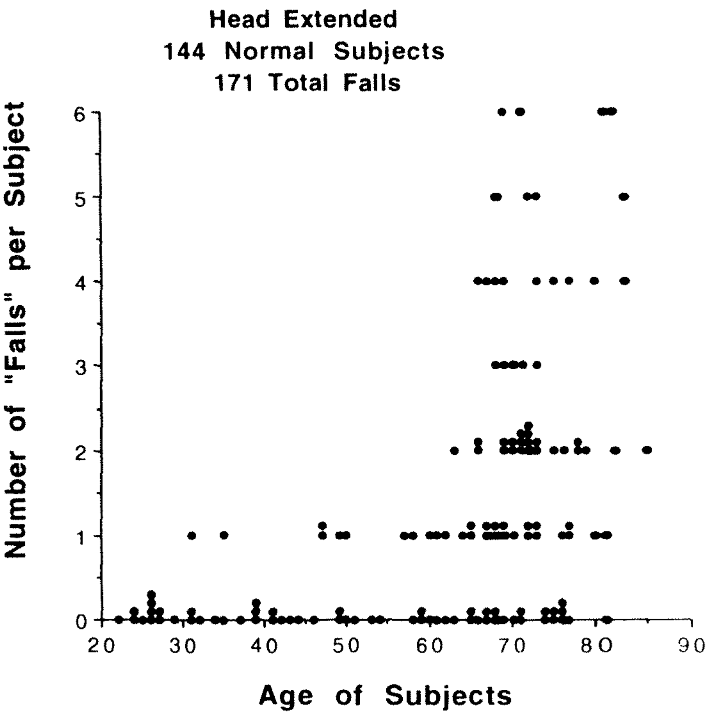

Figure 2.
The number of falls in the same population as in **Figure 1** but the tests were performed with the head extended 55°.

in the six trials with head erect. About 34 percent, or 35 of the 101 elderly subjects, fell at least once with their head erect. One hundred and nine of the 144 subjects (76 percent) exhibited no falls with head erect. The relationship of age to falls was highly significant (χ^2=66.76, p<0.001) if the 20–58 age group was compared to the 59–85 group. However, the χ^2 value was suspect because of the lack of falls in the younger group.

Most of our subjects fell more often with their head extended 55° (**Figure 2**). Seven subjects between age 31 and 58 showed a single fall. From age 59 through 85, 68 of the subjects exhibited 163 falls. Only 69 of the 144 subjects (48 percent) exhibited no falls with their head extended. Inspection of **Figure 2** shows that four subjects now exhibited six falls in the six trials where there was only one subject with this score with head erect. The 85 year old had two falls with his head extended. Once again, the relationship of age (20–58, 59–85) to falls was highly significant (χ^2=22.29, p<0.001). From computation of odds ratios (15), it was determined that the risk of falling is 46 times greater when the subject is older than age 58. When the subject is older than age 58, the risk of falling is 8 times greater if the head is extended.

There were no statistical differences between the number of falls in sensory test 5 and sensory test 6.

Further evidence that head extension increases the difficulty of certain posturographic tests is the comparison in the same subjects of falls in test 5 and 6 with head erect and then extended. None of the subjects up to age 59 had fewer falls with head extended than with head erect. Head extension either produced the same number of falls or more falls. In the 102 subjects in the age group from 59 to 85 (67 exhibited falls), only 2 subjects had one fewer falls with head extended than with head erect.

DISCUSSION

Two points are reinforced by the data from this study. First, elderly subjects, even those with no complaints or history of disequilibrium, had more difficulty maintaining balance with their heads erect when their postural control system is stressed by diminished or conflicting sensory input. Test conditions

5 and 6 have two abnormal sensory inputs. Condition 5 has no vision and diminished proprioception. Condition 6 has conflicting visual input and diminished proprioception. These elderly subjects seldom exhibited a loss of balance in the other four sensory organization tests.

Subjects younger than 59 years did not exhibit any falls with head erect in 3 trials of test 5 and 3 trials of test 6. In sensory test 5 of the protocol, the subject's eyes are closed and the test platform is sway-referenced. The subject strongly depends on the vestibular system to maintain balance. In sensory test 6, the eyes are open but the test platform and the visual surround are both sway-referenced. It is, therefore, confusing to subjects who depend greatly on accurate visual and ankle proprioceptive data to maintain balance.

These results are similar to those of Wolfson et al. (3). They also found that a loss of balance was uncommon among the young control subjects but occurred frequently in older subjects, especially during the first trials of sensory tests 5 and 6. Shepard et al. (6) also noted that the elderly exhibited more falls in sensory tests 5 and 6. Horak et al. (13) found that roughly 40 percent of asymptomatic elderly over age 70 fell in sensory condition 6 compared with less than 10 percent in young normal subjects.

Secondly, 55° head extension (versus head erect) has a significant (χ^2=18.94, p>0.001) effect on the number of falls induced in the elderly subjects. Even a few subjects in the third and fourth decade exhibited one fall. However, none of our younger subjects exhibited more than one fall. Head extension, like sway-referencing, increases the difficulty of maintaining balance under difficult conditions. We support Brandt's suggestion that head extension puts the utricle in a disadvantageous position (14). Brandt had suggested two possible reasons why head extension might increase postural sway. One is intermittent basilar insufficiency caused by functional compression of the vertebral artery, particularly in elderly patients with atheromata or with cervical spondylosis and osteophytes narrowing the transverse foramina. The other possibility was reduced accuracy of data from the utricular organs. As mentioned earlier, neither Brandt's patients nor our subjects showed any evidence or symptoms of ischemia. They also did not complain of arthritic neck pain with head extension.

Previously (8), we have discussed observations from others showing that head extension increases postural sway. Also, we mentioned the effects of head tilt, off-vertical rotation, and submental-vertex rotation on vestibulo-ocular reflexes. However, mechanisms other than utricular data loss may be the cause of increased sway. We had suggested previously that stretch receptor activity in the neck or just the relative novelty of the head position may weaken the overall control of balance.

We have added the head extension maneuver to our clinical protocol when testing patients with symptoms of disequilibrium. As would be expected, head extension increases the number of falls recorded (and decreases the equilibrium scores) in patients with balance problems. This was shown in a group of 121 patients reported previously (9) as well as a group of patients with Meniere's disease (11) and a group of patients with mild multiple sclerosis (12).

We were concerned that if one is to use falls with head extension as a criterion of abnormality in a patient that is being tested, it is necessary to know how often normal subjects fall under these circumstances. From the data described here, it would not be useful to use falls as a criterion of abnormality in subjects above about 60 years old. In subjects younger than 60, a single fall might indicate a minor weakness in the postural control but more than one fall would probably indicate an abnormality.

An abnormal number of falls in head extension trials could not be used as a differential test to assign the diagnosis of Meniere's disease or any other category of disequilibrium. Head extension appears to only make the test more difficult. It exposes patients with early Meniere's disease as well as those who have compensated for other relatively minor postural deficits.

The fairly dramatic change in the number of falls occurring near age 60 probably reflects partial degeneration in the visual, proprioceptive, and vestibular systems. As mentioned above, the subjects considered themselves physically fit and had no serious musculoskeletal deficits. They were urban and active in community affairs. They were not a random sample of people over 60 years. Presumably, a random sample would have produced more falls than this population.

CONCLUSION

Head extension increases the difficulty of certain dynamic posturography tests. The maneuver can be useful in uncovering compensated deficits in equilibrium in the young and middle-aged subject. However, posturographic falls are so common with head extension in the elderly that it is not a useful criterion to determine abnormality in this age group.

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