Doses of aminoglycosides are often therapeutically insufficient, however, and monitoring of the serum levels is required not only for ototoxicity but to ensure that adequate doses are administered.

We are grateful to Professor J D Williams for his comments and criticisms.

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Falls in the elderly related to postural imbalance

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Summary

Two hundred and forty-three elderly people aged 60 to 96 years were questioned about their falls, and their sway was measured. For comparison sway was also measured in 63 younger subjects. Sway increased with age and was higher in women at all ages. There was no difference in sway between those with and without history of falls and those who fell only because of tripping. In both sexes sway was significantly increased in people who fell because of loss of balance and in women whose falls were due to giddiness, drop attacks, turning the head, and rising from bed or a chair. This suggests that there is a physiological decline in postural control with advancing age and also a decline due to disease of the central nervous system.

Introduction

Although falls in the elderly are common and are associated with appreciable morbidity and mortality, there have been few investigations of their causes. In a random survey of the elderly population Sheldon found that 21% of men and 45% of women were affected. More recently, in a random sample of people over the age of 65 living at home, a history of falls was obtained in 24% of the men and 44% of the women. In both sexes the proportion who fell increased with age. Describing the pattern of falls in the elderly, Sheldon commented on the many accidental falls that were apparently caused by impaired balance. Although both young and old may trip over a kerb stone or lose their balance while descending stairs, the ability of the young to regain balance rapidly and avoid an actual fall is in strong contrast to what happens to the elderly. Not only are the elderly unable to correct their balance once they have stumbled but also there is probably a change in gait with age, resulting in the feet not being lifted as high as they used to be.
Another feature of falls in the elderly is that the proportion whose falls are due to tripping declines with increasing age. By contrast, drop attacks, giddiness, loss of balance, and postural hypotension are responsible for an increasing proportion of falls with advancing age.

Unsteadiness in standing was described by Romberg as a sign of disordered sensory-motor function, but Sheldon was the first to investigate in detail the changing pattern of unsteadiness with age. He showed that children have more postural sway than adults and that optimum control over these movements is achieved during the late teens and is maintained until about the age of 60, when there is a progressive rise in sway with age. More recently Hasselkus and Shambs have confirmed in a study on women that the elderly sway more than young adults. Sway has also been used to measure the degree of suggestibility in neurotic and normal individuals, although various workers have drawn different conclusions. In the present study we have investigated the association between falls and increased sway.

Subjects and methods

A total of 306 people were studied. They consisted of 243 elderly people (105 men and 138 women), whose ages ranged from 60 to 96 years (average 76 years), and, for comparison, 63 younger hospital workers (26 men and 37 women), whose ages ranged from 18 to 59 years. Most of the elderly people were living at home and were either seen at a social centre or were participants in a nutrition survey being conducted in the London Borough of Islington. Those not living at home were 28 army pensioners resident in the Royal Chelsea Hospital. A history was obtained of their falls, current drug treatment, and fractures sustained during the previous 25 years. Sitting and standing blood pressures were measured, and sway was recorded with the axiatrometer described by Wright. This portable apparatus consists of a box placed on the floor from which a vertical mast extends, which is attached by a thread to a belt around the subject's waist. Sway is expressed as total angular movement, summed regardless of sign, in the vertical plane only. Movements are communicated to a double ratchet mechanism in the box, which causes a pointer to rotate continuously over a calibrated dial, each unit of which represents 3 1/2° of angle of sway. Movements down to one minute of angle are detected.

The subjects, wearing outdoor shoes, stood with their feet comfortably apart and arms by their side. They were asked to look at a distant object and to stand as still as they could while the amount of sway was measured over one minute. The separation of the feet was not standardised and each subject was allowed to assume his position of optimum stability facing the axiatmeter. The test was repeated three times and the mean of the two lowest results was taken as the amount of sway.

Results

Sway increased (non-linearly) with age in both men and women (fig 1), and its distribution in the sample was positively skewed. Logarithmic transformation of sway made the relation with age become linear for both sexes and normalised its distribution. Regression lines for log sway on age, fitted separately for men and women, had slopes that were significantly different from zero (P < 0·001). Comparison of the regression lines for the two sexes indicated no difference between the slopes but a significant difference (P < 0·01) in elevation with the women having more sway than men.

The adequacy of the linear relation between log sway and age was tested by grouping the subjects into eight age groups, fitting regression lines to the means of these groups, and investigating the extent of deviation from linearity. There was no evidence of any departure from a linear relation in either men or women (fig 2).

The 243 subjects aged over 60 were divided into three main groups according to their history of falling. Group 1 consisted of 97 people who had had no falls; group 2 of 69 people who had fallen only because they tripped; and group 3 of 77 people who had had postural falls due to giddiness, drop attacks, loss of balance, turning the head, or rising from a bed or chair. Group 3 also included those who had had falls for unknown reasons or because of poor eyesight, weak legs, or collisions with furniture (miscellaneous cases). A subject's fall was classified as a drop attack if there was a clear history of an unexpected fall without loss of consciousness where no precipitating factor could be identified. Often these subjects reported that they could not stand up immediately afterwards. The causes of falls in table 1 were those identified by the 146 fallers, some of them having had more than one cause for their falls.

Table II shows the number of subjects and the mean log sway in each group. Comparisons between the means of group 1, 2, and 3 for each age group were made using the least significant difference following an analysis of variance. For both sexes there was no difference between the sway of group 1 and group 2, while the amount of sway in group 3 was significantly higher than that in group 2 for most age groups.

The individual causes of falling in group 3 were examined in more
TABLE III—Mean log sway adjusted for age of subjects classified by sex and cause of falling. Numbers in each group are given in parentheses

<table>
<thead>
<tr>
<th>Group</th>
<th>Adjusted mean log sway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td>No falls (group 1)</td>
<td>0.48 (55)</td>
</tr>
<tr>
<td>Giddiness</td>
<td>0.56 (5)</td>
</tr>
<tr>
<td>Drop attacks</td>
<td>0.50 (1)</td>
</tr>
<tr>
<td>Loss of balance</td>
<td>0.72 (6)</td>
</tr>
<tr>
<td>Turning head</td>
<td>0.49 (4)</td>
</tr>
<tr>
<td>After rising</td>
<td>0.49 (3)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.59 (6)</td>
</tr>
</tbody>
</table>

Significance of difference from adjusted mean of group 1: 1P < 0.05; 2P < 0.02; 3P < 0.01; 4P < 0.001.

Similar methods were used to examine the relation between sway and postural hypotension, fractures in the previous 25 years, the taking of drugs likely to increase sway, and the frequency of falling in the previous year. The three groups in table II were combined in this analysis.

Postural hypotension—This was defined as a fall in systolic pressure of 20 mm Hg or more between the sitting and standing position. It was present in 15 (14%) men and 22 (16%) women, and was not confined to those who fell after rising. The amount of sway was significantly greater in people with postural hypotension (men P < 0.02; women P < 0.05).

Fractures in previous 25 years—Only 8 (8%) men had a fracture, too few for statistical comparison. Fractures had occurred in 39 (28%) women, half of them affecting the wrist. No difference in the amount of sway was found between those subjects who had sustained fractures and those in the rest of the sample.

Drugs likely to increase sway—Subjects were included in this category if they gave a history of receiving night sedatives, antihypertensives, diuretics, phenothiazines, or benzodiazepines. Twenty-one (20%) men and 46 (33%) women gave such a history but there was no difference in amount of sway for either sex compared with those not receiving drugs.

Falls in previous year—All fallers were divided into three groups according to the number of falls they had had in the previous year: none, one to four, and five or more. Most people in both sexes had fallen between one and four times. No difference was found between the first two groups. Those who had had five or more falls, however, swayed more than those who had had one to four falls (men P < 0.02; women P < 0.05) and those who had had none (men P < 0.01; women P < 0.005).

Discussion

That elderly people sway more than young ones is not surprising, but it is interesting that this decline in postural control can be shown long before senescence. The finding that all ages women sway more than men is probably a function of the body weight: muscle mass ratio. Differences in footwear may have accounted for some of the increased sway but this was unlikely since none of the women tested were wearing high-heeled shoes.

No difference in sway was found in either sex between non-fallers and those who had fallen because of a trip. In both these groups there was less sway than in those who had fallen for reasons other than tripping. In women the amount of sway was significantly higher when falls had been due to giddiness, drop attacks, loss of balance, turning the head, or rising from bed or a chair. In men, although all these causes were associated with increased sway, only the results in the loss of balance group were statistically significant.

Hence probably postural control declines physiologically with age, and there is also a decline due to disease, as shown by the increased amount of sway in those who fell for reasons other than tripping. Tripping is an accident that can happen to anyone and is not necessarily associated with disease or increased sway.

Among the causes of falls tripping was found to be the commonest (47%). This compares with Sheldon's total for trips and accidental falls of 45%. Our figure for drop attacks of 12%, is lower than Sheldon's 25%, but is close to the 13% found in 536 women over the age of 65 by Exton-Smith. Once again the female preponderance in this disorder is confirmed; 20 women but only one man had suffered from drop attacks.

Exton-Smith showed that the type of fall is related to age in that there is a higher proportion of falls due to causes other than tripping in people aged over 75 years. We have found the same trend, and so did Brocklehurst et al in a study of fractures of the femoral neck.

The prevalence of postural hypotension in this sample was 15%. This was lower than the 24% found by Caird et al and the 17% found by Johnson et al, but in both these studies the postural fall in pressure was recorded between the lying and standing and not the sitting and standing positions.

Sheldon suggested that the change in sway with age was due to a change in the ability to control random movements that originated centrally, and that increased sway in the elderly was due to loss of cells in the brain stem and cerebellum. Hasselkus and Shambes agreed with the theory that ageing causes a decline in the central control of posture. Our finding that sway was increased in those subjects whose falls had been due to giddiness, drop attacks, and turning the head lends support to this theory, although reduced peripheral proprioceptive information in the elderly probably also plays an important part.

Numerous methods have been devised for measuring postural sway, but none of them has been brought into regular clinical use since either the equipment is expensive or inconvenient or the results obtained are not immediately available in a simple numerical form. The instrument used in this study has none of these drawbacks and has recently been modified so as to be small and light enough to fit into a pocket. We hope that further studies will be done with the ataxiometer to assess its value in predicting the likelihood of falls.

We thank Major-General R J G Morrison for permission to study patients under his care at the Royal Hospital, Chelsea; Mrs Grace Francis, Miss Christine Thornton, and Mrs Wendy Doyle for help during the project; Miss Ann O'Brien for secretarial work; and Dr B M Wright for helpful suggestions.

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Evaluation of $^{125}$I-fibrinogen test for venous thrombosis in patients with hip fractures: comparison between isotope scanning and necropsy findings

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Summary

The results of $^{125}$I-fibrinogen leg scanning during life were compared with the findings at a detailed post-mortem dissection of the leg veins in 31 patients with hip fractures who died during the period of isotope scanning or within seven days of the last scan. Thigh scanning on the side of the hip fracture proved valueless, and criteria for the confident isotopic diagnosis of venous thrombosis in the uninjured thigh could not be determined. In the lower leg a difference in uptake of $20\%$ or more that persisted for 24 hours between adjacent positions on one leg or between corresponding positions on the two legs was consistently associated with the presence of venous thrombosis at necropsy.

Introduction

The $^{125}$I-fibrinogen test for deep vein thrombosis has been used as an objective diagnostic aid in many clinical trials of potential antithrombotic agents, and the ability of agents to suppress isotopically diagnosed thrombosis has been used as a trial endpoint. During the past decade various criteria have been used to diagnose deep vein thrombosis but the most common are those that require a difference in uptake of $15\%$ or $20\%$ between adjacent positions on the same limb or between corresponding positions on the two limbs that persists for 24 hours or more. Close correlations between the results of scanning and venography have been found with both criteria, but the correlations have related mostly to calf vein thrombosis. Browse et al., however, found a good correlation between the results of scanning and venography in the middle and distal thirds of the thigh as well as in the calf in established venous thrombosis.

Methods

During a series of clinical trials in which the $^{125}$I-fibrinogen test was used in over 300 patients with hip fractures $^{11}$ 31 patients died during the scanning period or within seven days of the last scan. Detailed dissection of the leg veins was performed in those patients so that the results of isotope scanning during life could be compared with the necropsy findings.

$^{125}$I-fibrinogen scanning technique—Supplies of $^{125}$I-fibrinogen were obtained from the Radiochemical Centre, Amersham. Each patient received an intravenous injection of 100 $\mu$Ci of the labelled fibrinogen after the thyroid gland uptake had been suppressed by an intravenous injection of sodium iodide (100 mg). Oral sodium iodide (100 mg) was then administered twice daily for 28 days thereafter. The isotope was injected as soon as possible after admission, and the injection was never delayed more than 48 hours after the patient's admission to hospital. Scanning with a Nuclear Enterprises Scaler/Ratemeter (fitted with a GP7 scintillation probe) was performed daily thereafter, omitting weekends, for 10 days or until the patient died. At the initial examination the maximum count over the heart was obtained and this position was marked so that subsequent precordial counts could be obtained from the same position. Counting positions on the legs were also marked; these positions were at 5-cm intervals from the inguinal point down the medial aspect of the thigh over the course of the femoral vein and down the posterior aspect of the calf from the popliteal fossa to the ankle.

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