Ankle Reflex Stiffness During Unperceived Perturbation of Standing in Elderly Subjects

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Postural reflex activity during unperceived perturbation of standing was investigated in 38 elderly subjects (70–96 years old) and 10 younger adults (19–48 years old), and it was related to a history of unexplained falling in the 12 months prior to testing. Ankle torque (T) and ankle angle (A) were recorded during unperceived forward pulls to obtain the ankle stiffness (ΔT/ΔA), providing a measure of postural reflex activity at the ankle. Elderly nonfallers and younger adults had similar ranges of normalized ankle reflex stiffness. High ankle stiffness was significantly more common in elderly multiple fallers than in elderly nonfallers (p = .018). Furthermore, a majority of unstable elderly subjects who had reported a single unexplained fall also had unusually high ankle stiffness (p = .004). Multiple fallers and unstable subjects tended to overshoot backward on pull release in comparison with nonfallers (p = .003), which is suggestive of an overactive reflex response that might contribute to postural instability.

Impaired function of one or more of the vestibular, proprioceptive, and visual systems is likely to be a major contributor to falls in an elderly population (1–3). Researchers have proposed different clinical assessments to predict the risk of falling in elderly people and to target high-risk individuals for preventive intervention. Despite the established role of reflexes in maintaining an upright posture and stability (4–7), most of the proposed assessment tools have more emphasis on functional balance than on automatic postural reflex responses (1,8,9). Automatic long-latency reflexes play a major role in balance control, as they are faster and more stereotyped than voluntary movements and are more adaptable than segmental reflexes (6,7). Nashner (6) found that long-latency stretch reflexes increased ankle stiffness when the reflex response stabilized anterior–posterior sway motion. If the level of reflex-mediated stiffness of the ankle joint proved to be related to falling, then quantification of this reflex activity could prove useful in clinical assessment, addressing a fundamental component of postural control.

Most studies of postural reflexes have looked at responses to relatively sudden perturbations in order to isolate phases of reflex activity: latency of response onset is used to separate reflex from voluntary responses (see, e.g., 4,6,10). Woollacott and colleagues (10) described slightly greater reflex response latencies in the leg muscles of elderly subjects than in those of younger subjects, following anteroposterior displacement of the support surface, and they noted a degradation of the synergic responses of the upper and lower limb muscles in the elderly subjects. In contrast, unexpectedly rotational perturbations of the support surface in elderly subjects were reported to produce shorter reflex response latencies and even monosynaptic responses (uncommon in younger subjects). Both test situations would appear to represent somewhat extreme disturbances, comparable with a slip or trip. More recently, Tang and Woollacott (11) described lower reflex response amplitudes, as well as longer response latencies, in a study of simulated unexpected slips in elderly subjects.

The present study used a different approach, as described by Fitzpatrick and colleagues (12), who used an unperceived perturbation of stance to avoid evoking a voluntary response. Fitzpatrick and colleagues (12) measured the slope of the approximately linear relationship of ankle torque (T) to ankle angle (A) in young adult subjects during slow perturbation of normal standing, as a representation of ‘reflex muscle stiffness’ around the ankles (ΔT/ΔA). This reflex muscle stiffness was shown to be influenced by visual, vestibular, and proprioceptive sensory inputs, and it could be altered by ‘intentional set,’ that is, according to whether subjects were instructed to stand ‘still’ or ‘at ease.’ In the present study, this method was used to investigate whether disturbed ankle reflex function is a possible intrinsic factor that contributes to falling in elderly people (slips and trips would be extrinsic factors). The method was intended to mimic the conditions under which unexpected falling often occurs in the elderly population: during low-level activity and not accounted for by environmental causes or hazards (13,14).

Methods

Subjects

Forty-one subjects, 70 to 96 years of age, were recruited from a geriatric community complex, after interview with the help of a questionnaire to collect information on medical and falling history. Subjects were included if they were not...
suffering from acute illness, were capable of walking with or without aids in a domestic or laboratory setting, were able to follow instructions, and had no diagnosed neurological diseases such as stroke, Parkinson’s disease, or peripheral neuropathy. The recruited elderly subjects comprised 30 who were leading active, independent lives and 11 who were living in hostels and requiring domestic care. Classification of subjects was done before they underwent testing of postural reflexes. Subjects were categorized as multiple fallers (F), unstable (U), and nonfallers (NF) and were numbered so that their identities were concealed during the case study and data analysis. Ten relatively young adult subjects, 19–48 years of age, were recruited from University staff and students to provide normative data.

Classification was based primarily on falling history (Table 1), including the number of falls in the 12 months prior to testing and reasons (if any) for the falls. However, the aim of the study was to examine intrinsic causes of falling, so falls caused by identified extrinsic factors were discounted. Subjects classified as NFs were physically active and had experienced no falls in the 12 months prior to testing or had had one or two falls that were due to a clear extrinsic cause such as a trip on an obstacle. The 2 subjects included in this category who had experienced two falls had tripped twice on the same hazard. Three subjects who had reported no falls in the 12 months prior to testing were posturally very unstable and required wheelchair transport for distances of more than approximately 50 m. In this respect, they were strikingly different from the other NFs. All 3 required walking aids indoors, and 2 had started using walking aids after sustaining a fall more than 1 year prior to testing. Instead of including these subjects as NFs, we excluded them from further analysis. Subjects who had experienced only one unexplained fall in the 12 months prior to testing were grouped into the U category. Subjects who had reported two or more unexplained falls in the 12 months prior to testing were categorized as Fs.

The categorization of subjects was nonconventional (i.e., not based solely on number of falls, regardless of cause) and was intended to maximize the differentiation between subjects who fell and those who did not, so that a comparison of reflex activity between groups would not be confounded by heterogeneity within the groups. The project was approved by the Faculty of Health Sciences Human Ethics Committee, La Trobe University; informed consent was obtained from each participant.

Table 1. Number of Falls of Elderly Subjects, 12 Months Prior to Testing

<table>
<thead>
<tr>
<th>No. of Falls</th>
<th>NF</th>
<th>F</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>One</td>
<td>3 (E)</td>
<td>0</td>
<td>6 (UE)</td>
</tr>
<tr>
<td>Two</td>
<td>2 (E)</td>
<td>4 (UE)</td>
<td>0</td>
</tr>
<tr>
<td>More than two</td>
<td>0</td>
<td>8 (UE)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

Notes: NF = nonfaller; F = multiple faller; U = unstable; E = explained fall; UE = unexplained fall.

Three subjects were excluded from the analysis (see text for full explanation).

Apparatus

The apparatus for measuring the ankle torque and ankle angle was adapted from the study of Fitzpatrick and colleagues (12). It included a portable force platform with a singleforce gauge, servomotor, oscilloscope, position transducer, and a motor controller. A MacLab Scope data-acquisition system (ADInstruments Pty. Ltd., Sydney, Australia) and Apple Macintosh computer (Cupertino, CA) were used for recording and analysis. For measurement of the center of mass, a seesaw device was constructed by using a wooden plank (200 cm × 30 cm × 2 cm) with a fulcrum consisting of a wooden rod, 5 cm in diameter, attached at the center of the plank. Subjects were repositioned on the plank until balance was achieved. Height of center of mass was taken as the distance between the fulcrum and the heel position, marked on the plank with a set-square held against the sole of the foot.

Procedures

Each subject was measured for weight, height, and center of mass and stood barefoot on the force platform with heels slightly apart. A position transducer was connected to the subject’s leg at a height of 30 cm. Each subject was asked to stand in his or her normal comfortable position so that measurements were taken at close to normal physiological conditions. This position was recorded by the position and torque transducers, and the subject was instructed to return to this starting position before each trial by referring to a target circle on an oscilloscope display that monitored the changes in position and torque. The display was turned off during testing.

Each subject was connected at the waist to the servomotor by means of a weak spring with a length of 15 cm and a stiffness of 8.2 N m⁻¹. The servomotor produced perturbations consisting of a 4-second forward pull, a 2-second hold, and a 4-second release, at a rate of 2.3 cm per second. For each subject, changes in ankle torque and ankle angle were recorded and averaged for 20 perturbations. The onset of each perturbation was controlled by a manually operated switch, deliberately introducing a few seconds of variability in onset time, in order to avoid possible anticipation of the pull. During the perturbations, each subject’s response varied somewhat from trial to trial because the subject typically swayed forward and backward spontaneously, out of synchrony with the perturbation. Averaging was therefore essential to detect the response to perturbation, which was otherwise masked by postural “noise.” None of the subjects reported detecting the pull. Height of the ankle joint was measured at the lateral malleolus and was used for calculation of the change in ankle angle.

Analysis

Averaged data were displayed as an XY plot of ankle torque (T) against ankle angle (A) and were smoothed 10 times by using the MacLab Scope software. Smoothing did not produce any serious distortion of the recordings but removed high-frequency noise from the traces, making it easier to visualize the response to the perturbation. The majority (n = 30) of elderly subjects had a uniform average response during the whole period of the pulling phase (Figures 1 and 2), with an approximately linear average change
of ankle torque with ankle angle. The slope during the pull phase was often steeper than that during the release phase (Figures 2 and 3); only the pull phase slope was used for quantitative analysis. This was done by calculating the ratio of ankle stiffness (AS) to the subject’s load stiffness (LS), yielding a reflex stiffness ratio (RSR = AS/LS). The LS is a parameter related to the subject’s mass, height of center of mass, and angle obtained over a range of static positions, corresponding to that predicted by the physical dimensions of the subjects based on an inverted pendulum model of standing. Estimation of LS from direct measurement of ankle torque and ankle angle is convenient, as it can be done on the force platform by using the same settings as for recording responses to perturbation. However, some elderly people have difficulty in voluntarily swaying at the ankles as required by this method (15), resulting in inaccuracies in measurement of LS. Therefore, in the present study, LS was calculated by using physical dimensions. Assuming the body behaves as an inverted pendulum, torque (T) that is due to gravity acting at the ankles is given by \( mgh \times \sin \sigma \), where \( m \) is the subject’s mass, \( g \) is the acceleration caused by gravity, \( h \) is the subject’s height of center of mass, and \( \sigma \) is the ankle angle with respect to the vertical (Figure 4). For small values of \( \sigma \), this simplifies to \( mgh \sigma \). LS is represented by the slope, \( mgh \), of the relationship between \( T \) and \( \sigma \); as \( \sigma \) increases with forward leaning, \( T \) increases approximately linearly and must be counterbalanced by an equal and opposite torque generated by the ankle musculature (12).

Because the reflex muscle stiffness required to maintain stance will be dependent on a person’s weight and height, it is desirable to normalize for purposes of comparison. This was done by calculating the ratio of ankle stiffness (AS) to the subject’s load stiffness (LS), yielding a reflex stiffness ratio (RSR = AS/LS). The LS is a parameter related to the subject’s mass and height of center of mass, and it represents the changing load caused by gravity that the ankle musculature must counterbalance to maintain a standing posture (12; also see the paragraphs that follow).

Fitzpatrick and colleagues (12) found that LS, measured from the linear relationship between ankle torque and ankle angle obtained over a range of static positions, corresponded to that predicted by the physical dimensions of the subjects based on an inverted pendulum model of standing. Estimation of LS from direct measurement of ankle torque and ankle angle is convenient, as it can be done on the force platform by using the same settings as for recording responses to perturbation. However, some elderly people have difficulty in voluntarily swaying at the ankles as required by this method (15), resulting in inaccuracies in measurement of LS. Therefore, in the present study, LS was calculated by

where \( m \) is the subject’s mass, \( g \) is the acceleration due to gravity, \( h \) is the subject’s height of center of mass, and \( \sigma \) is the ankle angle with respect to the vertical (Figure 4). For small values of \( \sigma \), this simplifies to \( mgh \sigma \). LS is represented by the slope, \( mgh \), of the relationship between \( T \) and \( \sigma \); as \( \sigma \) increases with forward leaning, \( T \) increases approximately linearly and must be counterbalanced by an equal and opposite torque generated by the ankle musculature (12).

The AS/LS ratio must be greater than 1 to allow standing; higher ratios indicate a more rigid stance. Fitzpatrick and colleagues (12) concluded that changes in AS were the result of changing reflex excitability. Hence, a high level of postural reflex activity should be reflected in a high RSR. Although there would be a contribution to AS of passive elastic and viscous properties of muscles and joints, these passive components of joint stiffness are relatively small as they are obviously unavailable to maintain stance (an unconscious or paralyzed person cannot stand unsupported). On this basis, it can be argued that the RSR is determined predominantly by neurally mediated muscle stiffness.

For 8 elderly subjects, it was not possible to estimate the slope of the torque-to-angle relationship in a consistent way, because the trace had nonlinear phasic components. Furthermore, in 5 of these subjects, the overall slope during the forward pull appeared to be very steep, approaching infinity (Figure 3). Therefore, for all data for quantitative analysis to be included, a nonparametric approach was used. Subjects were categorized according to whether their RSR was less
than or greater than 2. This criterion was arbitrarily based on the observation that the majority of NFs (90%) and younger adult subjects (80%) had a RSR of less than 2. A slope of twice the LS was superimposed on the corresponding curve of individual subjects for whom the stiffness ratio could not be determined and was used to differentiate these subjects into either category. In all cases, the initial slope during the forward pull was clearly greater than twice LS, with later components that were often steeper or even negative as the subject strongly resisted the pull or moved backward (Figure 3).

Qualitative analysis was also applied to the entire pattern of the response, in terms of direction and amplitude of swaying during the entire 10 seconds of pull and release. Five distinct response patterns were identified (see Results). Because of the necessity for categorization of data to avoid bias, nonparametric methods were generally used for statistical comparison of groups: either the chi-square test was used, or the Fisher exact probability test was used when the assumptions of the chi-square test were not satisfied (16).

Figure 3. Average response (20 trials) to perturbation in subject F35, a multiple faller. Displacement to the right on the abscissa represents a forward sway (deg). Upward displacement on the ordinate represents an increase in ankle torque (Nm). The solid line is the superimposed slope of twice the calculated load stiffness of this subject. On average, the subject was almost stationary during the pull, but the ankle torque increased, thereby making the overall slope of this section, 1 to 5 seconds, very high and clearly greater than twice the load stiffness. The trace shows a phasic component immediately after pull onset: the initial slope was less steep than the overall slope but also greater than twice load stiffness. During the holding phase from 5 to 7 seconds and the release phase from 7 to 12 seconds, the subject tended to move backward, overshooting the starting position. This response pattern demonstrates a strong opposition to the unperceived pull.

Table 2. Characteristics of Elderly Subjects

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>NF</th>
<th>F</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) ± SD</td>
<td>81.4±6.6</td>
<td>85.4±5.6</td>
<td>86.2±6.4</td>
</tr>
<tr>
<td>No. of subjects</td>
<td>20</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Female</td>
<td>12/20 (60%)</td>
<td>11/12 (92%)</td>
<td>6/6 (100%)</td>
</tr>
<tr>
<td>Walking aid user</td>
<td>6/20 (30%)</td>
<td>9/12 (75%)</td>
<td>6/6 (100%)</td>
</tr>
<tr>
<td>Visual impairment†</td>
<td>8/20 (40%)</td>
<td>9/12 (75%)</td>
<td>4/6 (67%)</td>
</tr>
<tr>
<td>Engaging in regular exercise†</td>
<td>13/20 (65%)</td>
<td>6/12 (50%)</td>
<td>4/6 (67%)</td>
</tr>
</tbody>
</table>

Notes: NF = nonfaller; F = multiple faller; U = unstable; SD = standard deviation.
†Visual impairments included cataract (with or without cataract surgery) and other nonrefractive impairments.
Excercise included walking and gentle mobility exercises.
subject's tendency to resist displacement and overshoot backward when the pull was released. Groups III, IV, and V were combined because these subjects showed a clear forward sway during the pull and did not overshoot backward on release, or returned close to the starting position. For the chi-squared test to be applied it was further necessary to combine the F and U groups. The observed frequency distribution was significantly different from that expected by chance ($p = .003$). Fisher exact probability tests (two-tailed) indicated a significant difference between F and NF groups ($p = .018$), between U and NF groups ($p = .004$). Note that although the distribution in Table 6 appears to be identical to that of Table 4, this is fortuitous; the membership of the groups was similar but not identical.

A qualitative analysis of response patterns therefore showed that the Us and Fs were significantly different from the NFs in that a majority in both groups overshot backward after release of a forward pull. This pattern of response was rare in the NF group. Examination of the RSRs obtained in the quantitative analysis revealed a correlation with the qualitative reflex response patterns. Mean RSRs for Groups I, II, III, IV, and V were $>2$, $2.5$ ($SD = 0.8$), $1.6$ ($SD = 0.56$), $1.6$ ($SD = 0.4$), and $1.7$ ($SD = 0.4$), respectively. The

### Table 3. RSR of Elderly and Younger Adult Subjects

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NF</th>
<th>F</th>
<th>U</th>
<th>YA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>1.73 ± 0.57</td>
<td>1.69 ± 0.76</td>
<td>2.6 ± 0.84</td>
<td>1.59 ± 0.47</td>
</tr>
<tr>
<td>Range</td>
<td>1.2–3.3</td>
<td>1.1–3.1</td>
<td>1.49–3.2</td>
<td>1.0–2.6</td>
</tr>
<tr>
<td>n</td>
<td>19</td>
<td>7</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

***Notes***: NF = nonfaller; F = multiple faller; U = unstable; YA = younger adult; SD = standard deviation; RSR = reflex stiffness ratio, i.e., ankle stiffness to load stiffness. There was no significant difference between groups (F test, $p = .07$). The table excludes 8 subjects for whom a consistent value of ankle stiffness could not be obtained.

### Table 4. Distribution of Elderly Subjects with RSR Greater Than 2

<table>
<thead>
<tr>
<th>Group</th>
<th>RSR &gt; 2</th>
<th>RSR ≤ 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF</td>
<td>3 (15%)</td>
<td>17 (85%)</td>
<td>20</td>
</tr>
<tr>
<td>F</td>
<td>7 (58%)</td>
<td>5 (42%)</td>
<td>12</td>
</tr>
<tr>
<td>U</td>
<td>5 (83%)</td>
<td>1 (17%)</td>
<td>6</td>
</tr>
</tbody>
</table>

***Notes***: NF = nonfaller; F = multiple faller; U = unstable; RSR = reflex stiffness ratio, i.e., ankle stiffness to load stiffness. The combined F + U group, which had a higher proportion of RSRs greater than 2, was significantly different from the NF group (chi-square test, $p = .003$).

### Table 5. Distribution of Elderly Subjects, According to Different Response Patterns

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF</td>
<td>1</td>
<td>2</td>
<td>11</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>U</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>7</td>
<td>14</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

***Notes***: NF = nonfaller; F = multiple faller; U = unstable. See text for full description of group characteristics. Groups I and II showed overshoot on release of pull; Group III returned close to starting position; Groups IV and V did not return to starting position.

### Table 6. Comparison of Responses in Groups I and II and Groups III, IV, and V in Elderly Subjects

<table>
<thead>
<tr>
<th>Group</th>
<th>Groups I, II</th>
<th>Groups III, IV, V</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NF</td>
<td>3</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>F</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>U</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

***Notes***: NF = nonfaller; F = multiple faller; U = unstable. Group I and II responses were common in F and U subjects, but rarely observed in NF subjects. The difference in distribution of responses was highly significant (chi-square test combining categories F and U, $p = .003$).
ANKLE REFLEX STIFFNESS IN ELDERLY SUBJECTS

The present study is the first to use the method of unperceived perturbation to examine the relationship between postural reflex activity and falling in an elderly population. Because the perturbations were not perceived, it can be argued that the responses observed were due to involuntary or reflex activity. Other studies, which have used sudden displacements of the support surface to induce reflex responses, may not adequately represent the mechanisms that operate during normal quiet standing.

The majority of the NF group had experienced no falls in the 12 months prior to testing, but the group included subjects with one or two explained falls (i.e., caused by a trip or slip on a hazard). The inclusion in the NF group of what might elsewhere be categorized as “multiple fallers” is consistent with the aim of the study, which is to examine the relationship between unexplained falls and postural reflex activity.

Similarly, the exclusion from the NF group of 3 subjects who, on the basis of history alone, would normally be classified as “nonfallers” was justified on the basis of the severity of their postural instability, which clearly distinguished them from other NFs. It is likely that these subjects had reduced their risk of falling through a reliance on walking aids.

The results show that the overall level of postural reflex activity at the ankles in elderly NFs of over 70 years of age is comparable, during mild perturbation of balance, with that of younger adults of less than 50 years of age. This is illustrated by the mean ankle RSR values of 1.73 in elderly NFs and 1.59 in younger adults (Table 3). However, a high percentage of Fs and Us display unusually high RSRs. Therefore, despite the evidence of a general decline of sensory and motor functioning in elderly people caused by aging (3,17), the results of the present study demonstrate that elderly people with evidence of postural instability are likely to possess an unusually strong postural reflex response to mild postural disturbance. However, if the postural reflex response is exaggerated, as suggested by the “overshooting” reactions seen in the present study, this may lead to instability when these people are facing postural disturbances, thereby possibly contributing to unexplained falling problems.

The concept that overactive postural reflex activity could cause postural instability is not new and has been proposed by researchers investigating modulation of the soleus Hoffman reflex (H reflex) under varying postural conditions (18,19). Young adults depress soleus H-reflex amplitude when they stand, compared with a prone position, whereas elderly subjects on average have lower H-reflex amplitudes but show an increase in amplitude on standing. In particular, failure to depress the soleus H reflex in elderly subjects was associated with greater postural instability, as measured by area of sway (18), which is an observation that supports the present findings.

This interpretation also broadly agrees with the conclusion of Woollacott and colleagues (10) that there is an increased (and perhaps maladaptive) reliance on the functional stretch reflex in the elderly population. Although Woollacott and colleagues (10) focused on the latencies and synergies of postural reflexes and did not directly comment on their magnitude, they did report a very high incidence (82%) of monosynaptic stretch reflexes in leg muscles of elderly subjects in response to ankle rotation, in comparison with young adults (less than 25%). This is suggestive of the presence of overactive stretch reflexes in many of their elderly subjects and is consistent, at least in qualitative terms, with the present finding of a high AS in a subgroup of elderly subjects.

However, Tang and Woollacott (11) subsequently reported decreased reflex response amplitudes in an elderly population, in a study of simulated slips. There is a likely explanation for this apparent discrepancy. The more extreme response evoked by a sudden postural disturbance may well be limited by deterioration of sensorimotor function in an elderly population. In contrast, the response to a mild unperceived disturbance, such as that used in the present study, is more likely to be within the subject’s maximal capacity to respond, even if there is deterioration of sensorimotor function. If this is the case, there is potential for the response to a mild perturbation to be exaggerated above what is normal or optimal.

The mechanism by which high AS develops in elderly people who fall requires elucidation. It is possible that falling itself could be a contributory factor, causing the subjects to become more cautious or develop a fear of falling. Such a change in mental set might well lead to an increase in postural reflex activity, as shown by Fitzpatrick and colleagues (12) in normal young adults when asked to stand still in comparison with standing at ease. In addition, a possible contribution to increased AS of long-term changes in passive ankle properties might be significant in subjects suffering from serious arthritic disorders.

Although many subjects in the F group had high RSRs, there were marked differences within the group, with some subjects displaying a RSR close to 1. This might be related to reduced proprioceptive input at the ankle joint (1,3) or deterioration of ankle musculature (20), which might be expected to decrease reflex activity. However, a low RSR was also commonly observed in NFs and in healthy younger adults (Table 3) and is therefore not necessarily an indication of reflex impairment.

Other factors that might contribute to falling in an elderly population were not formally examined in the present study. However, the data obtained by questionnaire (Table 2) indicate that subjects in the F and U groups were characteristically female, highly dependent on walking aids, and more likely to be suffering from visual impairment than NFs. This is consistent with other studies that have shown that falling is more common in elderly females than males (21) and that visual input is of greatest importance for balance control in people over the age of 75 (22,23). The high use of walking aids by Fs (75%) and Us (100%) is consistent with their postural instability. Because heavy reliance on walking aids might be expected to reduce dependency on postural reflexes for balance control, this could be a factor leading to inappropriate changes in reflex behavior and warrants further investigation.
The measurement of postural responses to perturbation could be valuable in assessing the degree of low-level reflex activity and in reassessing the progress of a person’s balance after therapeutic intervention. The present quantitative methods are more suited to a research laboratory, but a qualitative approach aimed simply at detecting overcorrection of postural disturbances could be practicable in a clinical setting. Unusually high or exaggerated reflex responsiveness to mild postural disturbance could be an indicator of falling risk, but it should be recognized that many elderly people who fall have levels of postural reflex activity that overlap with those of elderly people who do not fall and younger adults.

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References