Stance control is not affected by paresis and reflex hyperexcitability: the case of spastic patients

A Nardone, M Galante, B Lucas, M Schieppati

Abstract

Objectives—Spastic patients were studied to understand whether stance unsteadiness is associated with changes in the control of voluntary force, muscle tone, or reflex excitability, rather than to abnormal posture connected to the motor deficit itself.

Methods—Twenty four normal subjects, 12 patients affected by amyotrophic lateral sclerosis (ALS), seven by spastic paraparesis, and 14 by hemiparesis were studied. All patients featured various degrees of spasticity and paresis but were free from clinically evident sensory deficits. Body sway during quiet upright stance was assessed through a stabilometric platform under both eyes open (EO) and eyes closed (EC) conditions. The sudden rotation of a supporting platform, in a toe up and toe down direction respectively, evoked short (SLR) and medium latency (MLR) reflex responses to stretch of the soleus or the tibialis anterior (TA) muscle.

Results—No relation was found between clinical findings (tone, muscle strength, tendion reflexes, planar response, and duration of disease) and body sway. On average, all patient groups exhibited a forward shift of the centre of foot pressure (CFP) with respect to normal subjects; in addition, paraparetic and to a much larger extent hemiparetic patients showed a lateral shift of CFP. Body sway area was significantly increased only in the hemiparetic patients. No relation was found between position of the CFP and sway within any patient group. Soleus SLR was increased in all patients with respect to normal subjects. TA SLR was often seen in both patients with ALS and paraparetic patients, but only rarely in normal subjects and hemiparetic patients. However, no relation was found between amplitude of soleus or TA SLRs and stabilometric variables. The frequency and size of soleus MLRs and TA MLRs were decreased in all patients. These responses were decreased in size and not modulated by background EMG in the affected leg of hemiparetic patients, suggesting a disturbed control of spinal reflexes fed by spindle group II afferent fibres.

Conclusions—It is proposed that body posture, paresis, or monosynaptic reflex hyperexcitability do not affect the control of equilibrium during quiet upright stance. In hemiparetic patients, the decreased amplitude of MLRs might be the main cause of the large postural instability. The results are congruent with the hypothesis of a role for group II afferent input in the reflex control of equilibrium. (J Neurol Neurosurg Psychiatry 2001;70:635–643)

Keywords: spasticity; stance; body sway; reflex responses

The control of human upright stance relies on multiple sensory inputs, their central integration, and appropriate reflex and voluntary motor output. Despite many studies on the role of afferent input in the control of body sway during quiet stance,1 an analysis of the effects produced by lesions of the motor system has not been systematically pursued. Patients with cerebrovascular accidents sway to a larger extent than normal subjects2 3; however, it is not clear whether unsteadiness is a direct consequence of the motor deficit itself (decrease in muscle strength, asymmetric support) or of the changes in the control of voluntary force or muscle tone and reflex excitability, accompanying the physiological changes in the central organisation of motor activity.

Reportedly, changes in muscle postural tone and stretch reflex excitability can produce abnormal sway.4 On the other hand, recent results from this laboratory have shown that patients affected by large fibre peripheral neuropathy do not necessarily present with increased body sway despite decreased muscle force and absence of tendon reflex.5 In the present investigation, we analysed the characteristics of quiet upright stance in a group of spastic patients affected by various lesions of the CNS. These lesions have in common alterations of descending motor pathways leading to decreased muscle force and increased muscle tone and spinal reflex excitability. Contrary to polineuropathic patients, spastic patients show hyperactive tendon jerks. To check the possibility that changes in stretch reflex excitability produce abnormal sway, we analysed latency and amplitude of the reflex responses evoked in the leg muscles by perturbations of upright posture delivered by a mobile platform.

Although the input from the skin receptors of the foot sole may contribute to the control of stance in normal subjects,6 no information exists about the possible effects on stance of an abnormal central processing of the cutaneous input. In spastic patients, such abnormality is witnessed by the reversed sign of the cutaneous plantar response, which occurs as a consequence of upper motor neuron lesions.7 Therefore, we
considered the relation between sway and the Babinski sign as well.

A further cause of changes in body sway in spastic patients might be their abnormal postural attitude, as sway amplitude depends on the anterior-posterior position of the projection of the body centre of mass on the base of support in normal subjects.\(^4\) To therefore, a second aim of this study was to check the possible dependence of increased body sway on peripheral conditions, such as degree or asymmetry of muscle strength and abnormal position of body centre of mass, typical sequelae in hemiparetic patients.

**Methods**

**PATIENTS**

The study was performed on 33 spastic patients and 24 normal subjects. The patient group was characterised as follows: 12 patients with sporadic amyotrophic lateral sclerosis (ALS), mean age 56.9 years (SD 10.1) (range 39–73), seven with spastic paraparesis, mean age 53.1 (SD 10.7) (range 39–67), and 14 with stroke, mean age 56.6 (SD 13.5) (range 29–80). Although the onset of ALS was apparently localised at spinal level, a variable degree of upper motor neuron syndrome was present. Four paraparetic patients were affected by Strümpell-Lorrain disease, two by idiopathic spastic paraparesis, and one by sequelae of meningioma of the falx cerebri. Eight of the hemiparetic patients showed right hemiparesis, six left hemiparesis. In three, the lesion was localised at the cortical grey matter, whereas in the other 11 the lesion involved also the subcortical white matter, mainly in the territory of the medial cerebral artery. In no patient was the right posterior parietal cortex, which is involved in the processing of spatial information,\(^1\) affected by the vascular lesion. All patients were deliberately recruited only if free from clinical sensory deficits. Mean duration of disease was 1.4 (SD 1.0), 11.0 (SD 10.1), and 0.7 (SD 0.8) years for patients with ALS, and paraparetic and hemiparetic patients, respectively. Patients were able to stand upright and walk without aids. All were enrolled in a rehabilitation programme aimed at improving gross motor function (rolling, sit to stand, transferring), upper limb function, and gait. Bobath techniques were utilised. Due to the different types of disease, patients entered the study at different times from the onset of disease. As a consequence, some patients were enrolled some weeks after rehabilitation, other patients at the start. The control group was made up of a sample of 24 subjects, mean age 58.6 years (SD 12.1) (range 41–83). They had never had metabolic, neurological, or vestibular disease, did not take drugs known to affect the CNS, and their present neurological examination was unremarkable. All subjects and patients gave their informed consent to the protocol, and the local ethics committee approved the study.

**ANALYSIS OF POSTURE**

Body sway during quiet stance was recorded by means of a dynamometric platform (Kistler model 9281B). Patients stood upright barefoot with eyes open (EO) gazing at a target placed at a distance of 50 cm at eye level, and with eyes closed (EC). Feet were parallel, spaced 10 cm apart. Two trials, of 52 seconds duration each, were recorded for each visual condition. The forces acting on the platform were acquired and the changes in the position of their resultant vector (the instantaneous CFP) were measured according to the methods described in a previous paper.\(^2\) From the instantaneous positions of the CFP, the mean position of the CFP was calculated. The mean CFP on the anterior-posterior (A-P) axis in reference to the calcaneum was expressed as a percentage of the total foot length to normalise all the subjects’ data. Position of the CFP along the mediolateral axis (CFP-ML) was also calculated: negative and positive values (mm) corresponded to right and left shift of CFP, respectively, with regard to the A-P axis of symmetry. To normalise the subjects’ data, the CFP-ML was expressed as a percentage of body height. The body sway area was the surface (mm\(^2\)) swept during the trial by the line joining the mean CFP to the moving instantaneous CFP.\(^3\)

**REFLEX RESPONSES TO PERTURBATIONS**

Postural reactions to upright stance perturbations were elicited by sudden rotations of a supporting platform. Upward (toe up) rotations stretched the triceps surae muscle, downward rotations (toe down) stretched the tibialis anterior (TA). Velocity and amplitude of rotation were 50°/s and 3°. Surface EMG of the soleus and TA muscles were bilaterally recorded. Raw EMG signals were filtered (100 Hz-3 kHz, -6 dB/octave), amplified (×10 000) and fed to a computer (sampling frequency 1 kHz). EMG activity was off line full wave rectified, and then averaged over 10–20 corresponding postural perturbations. EMG responses were measured with a cursor on the computer screen. The responses in the
Table 1Mean (SD) scores for clinical findings in patients

<table>
<thead>
<tr>
<th>Type of assessment</th>
<th>ALS patients</th>
<th>Paraparetic patients</th>
<th>Hemiparetic patients (affected leg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle tone of foot plantarflexor muscles (modified Ashworth scale): 0–5</td>
<td>1.3 (1.4)</td>
<td>2.6 (1.4)</td>
<td>1.4 (1.2)</td>
</tr>
<tr>
<td>Foot dorsiflexor muscles (MI): 0–3</td>
<td>25.4 (9.1)</td>
<td>23.0 (8.2)</td>
<td>19.5 (4.1)</td>
</tr>
<tr>
<td>Quadriceps tendon reflex (MRS): 0–4</td>
<td>3.1 (0.7)</td>
<td>3.4 (0.8)</td>
<td>3.4 (1.1)</td>
</tr>
<tr>
<td>Achilles tendon reflex (MRS): 0–4</td>
<td>3.0 (0.8)</td>
<td>3.2 (0.8)</td>
<td>3.4 (0.6)</td>
</tr>
<tr>
<td>Plantar response (Norris scale): 0–3</td>
<td>1.3 (1.2)</td>
<td>0.8 (1.0)</td>
<td>0.9 (1.3)</td>
</tr>
</tbody>
</table>

MI=Motricity index; MRS=myotatic reflex scale.

The findings obtained in the stabilometric tests were analysed separately according to the visual conditions (EO, EC). Two trials for each condition were considered for all subjects. As body sway area was not normally distributed, normalisation was obtained by logarithmic transformation. Two way ANOVA (with patient groups as the independent variable and visual conditions as the repeated measures) was performed for all sway variables. For reflex responses to perturbations, one way ANOVA was used for assessing differences between the sample of normal subjects and the three groups of patients. For each response, subjects entered the analysis with two observations corresponding to the right and left leg. For hemiparetic patients, the responses from the right and left leg were pooled according to the affected and healthy side. An F value leading to p<0.05 was considered significant. The post hoc test was the Newman-Keuls test. In hemiparetic patients, the area of the responses occurring in the affected and healthy limb were compared through the paired t test. The mean frequency of occurrence of the reflex responses to perturbation was calculated for all groups. For hemiparetic patients, frequency of occurrence was separately calculated for the affected and healthy leg. Any difference in the frequency of occurrence of each response between normal subjects and patients was assessed with a χ² test.

**Results**

**CLINICAL FINDINGS**

Muscle tone, strength, tendon reflexes, and plantar response were clinically assessed in the lower limbs of all patients (table 1). On average, muscle tone was increased in all of them. One way ANOVA showed that muscle tone was significantly (F=5.1, df=2, 49, p<0.01) different between ALS, paraparetic, and hemiparetic patients. The post hoc test showed a significantly greater degree of muscle tone in paraparetic patients than in patients with ALS (Newman-Keuls, p<0.02) or the affected limb of hemiparetic patients (Newman-Keuls, p<0.01). Despite the large between group difference in disease duration, the severity of other clinical signs was not statistically different between the three groups of patients, thus suggesting that the severity of the disease affecting the motor abilities was homogeneous within each group of patients.

**CHARACTERISTICS OF POSTURE**

**Sway area**

Figure 1 shows an example of body sway recorded during quiet stance under EO and EC conditions in a normal subject and in representative patients affected by ALS, paraparesis, or left hemiparesis. The hemiparetic patient swayed to a larger extent than the normal subject, the patient with ALS or the paraparetic patient. The CFP of the three patients was displaced slightly forwards with respect to the normal subject. In addition, in the hemiparetic patient the CFP was shifted toward the unaffected limb.

Figure 2 summarises the results of body sway variables in the normal subjects and in the three patient groups standing quietly under both EO and EC conditions. The graph shows that sway area was within normal limits in patients with ALS and paraparetic patients, but was greatly increased in hemiparetic patients. A two way ANOVA performed on body sway area showed a significant difference between groups (F=9.3, df=3, 105, p<0.0001) and between visual conditions (F=113.8, df=1, 105, p<0.0001). A significant (p<0.02) interaction was found between groups and visual conditions, indicating that closing the eyes did not increase body sway area to the same proportion in all groups. The post hoc test showed that the body sway area of patients with ALS and paraparetic patients was not significantly different from that of normal subjects, whereas the body...
Sway area of hemiparetic patients was significantly larger (Newman-Keuls, p<0.0002) under both visual conditions.

Centre of foot pressure
Under both visual conditions, the position of CFP A-P (in % of foot length) was shifted significantly forward (p<0.0002) in all groups of patients with respect to normal subjects (figure 2, middle graph). A two way ANOVA on the position of the CFP along the A-P axis showed significant differences between groups (F=6.8, df=3, 105, p<0.0005) but not between visual conditions. There was a moderate forward shift in the paraparetic (Newman-Keuls, p<0.002) and hemiparetic patients (Newman-Keuls, p<0.05) with respect to the other groups. For position of the CFP along the M-L axis (in % of subject height), paraparetic patients showed a slightly greater lateral shift of CFP than the normal subjects and patients with ALS (Newman-Keuls, p<0.05). In hemiparetic patients, the CFP was most affected: these patients had a significantly greater (Newman-Keuls, p<0.0002) lateral shift than all other groups, under both visual conditions. Any effect of the A-P or M-L position of the CFP on sway area was assessed. When all patient data were collapsed, the regression between these variables was significant because of the hemiparetic group mean effect; however, within no patient group, hemiparetic patients included, was any relation between body sway area and CFP found. To better weigh up the influence, if any, of M-L position of the CFP on sway area, we compared sway in a subgroup of ALS plus paraparetic patients with respect to a subgroup of hemiparetic patients. The two groups (consisting of eight patients each) had the same M-L CFP. In the ALS plus paraparetic and in the hemiparetic group, the M-L CFP was respectively 1.36 % (0.29) and 1.39% (0.29) with EO, and 1.35% (0.31) and 1.05% (0.5) with EC. Despite the same M-L CFP values in the two groups, the corresponding sway area was significantly (p<0.005,
Stance control and spasticity

Interestingly, no effect on sway area was exerted by the characteristics of the plantar response: (a) within each group there was no relation between type of plantar response and amplitude of sway; (b) by collapsing all patients’ sway in four categories on the basis of the type of response (flexor, mute, equivocal, extensor), no significant or quasi-significant differences were seen. No relation was found between sway or CFP position variables (recorded with EO or EC) and clinical findings in any group of patients. Neither the side (right or left) nor the main localisation of the lesion (frontal, parietal, or frontotemporoparietal) affected the sway variables. In particular, in hemiparetic patients, no change in severity was found in either body sway area or CFP position in the A-P or M-L direction when the patients were divided into two groups on the basis of the side of the lesion. Duration of disease did not affect stabilometric findings, suggesting that the severity of disease was homogeneous within each group of patients.

Relation between stabilometric and clinical findings

A two way ANOVA was performed between stabilometric variables and clinical variables as muscle tone, strength, tendon reflexes, plantar response, and duration of disease, separately considered. Interestingly, no effect on sway

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those with spastic paraparesis, this frequency was significantly (χ²) higher than that in normal subjects, patients with ALS and hemiparetic patients. In the affected and healthy limb of hemiparetic patients, the TA SLR occurred respectively at a frequency of 29% and 21%, neither frequency being significantly different from that in normal subjects.

The frequency of occurrence of the soleus MLR was not significantly different from that of normal subjects, being 92%, 93%, and 93%, respectively in patients with ALS, paraparetic patients, and in the affected leg of hemiparetic patients. On the contrary, the frequency of TA MLR was significantly (p<0.01) decreased in all patient groups compared with normal subjects, being 63%, 86%, and 71%, respectively in patients with ALS, paraparetic patients, and in the affected leg of hemiparetic patients. In the healthy leg of the hemiparetic patients, TA MLR occurred with a frequency of 100%, a value significantly higher than that in the contralateral limb.

**Latency and area of EMG responses**

The latency of the TA-SLR was about 47 ms—that is, similar to that of the soleus SLR—thus suggesting that both responses are monosynaptic or oligosynaptic in nature. The latency of the other responses was not significantly different from that in normal subjects.

Abnormalities in size (fig 4) were found in both limbs of the patients except for the healthy limb of hemiparetic patients, which showed EMG responses similar to those of normal subjects.

The soleus SLR corresponds to the monosynaptic stretch reflex, and its increased excitability in patients (F=5.0, df=3, 91, p<0.005) is a well known sign of spasticity. On average, the area of soleus SLR to toe up rotation was enlarged (Newman-Keuls, p<0.05) in patients with ALS and paraparetic patients and marginally (p<0.06) so in the hemiparetic patients with respect to normal subjects. The soleus SLR was significantly larger (paired t test, p<0.05) in the healthy leg of hemiparetic patients.

The area of soleus MLR showed minor and non-specific differences between groups (F=2.5, df=3, 33, p<0.07). In hemiparetic patients, the soleus MLR was marginally

![Figure 3 Example of recording of EMG responses of soleus (sol) and tibialis anterior (TA) muscles induced by toe up and toe down rotations of the supporting platform in a normal subject, a patient with ALS, a paraparetic, and a left hemiparetic patient. SLR=short latency response; MLR=medium latency response. In all subjects, each panel shows the superimposition of the average of 20 rectified and filtered (time constant=1 ms) EMG responses from the right (thin line) and left leg (thick line), or affected and non-affected leg for the hemiparetic patient. Note the increased amplitude of the sol SLR in the patients with respect to the normal subject, and the occurrence of the TA SLR in patients with ALS and paraparetic patients. At variance with soleus SLR and TA SLR, soleus MLR and TA-MLR are decreased in amplitude in the affected limb of the hemiparetic patient. Vertical dotted lines indicate the onset of platform displacement.](http://jnnp.bmj.com/ on June 14, 2022 by guest. Protected by copyright.)
R patients (y=1.77x+0.03, p<0.03, R paretic patients (y=3.80x–0.71, p<0.0001, maintained and reached significance in para-

responses, the regression between the relevant responses and the background was considered: soleus SLR (y=0.32x+0.20, p=0.01), soleus MLR (y=0.42x+0.13, p<0.003, R^2=0.20). In patients, despite the large variability in the responses, the regression between the relevant background and area of the soleus SLR was maintained and reached significance in paraparetic patients (y=3.80x–0.71, p<0.0001, R^2=0.75) and the affected leg of hemiparetic patients (y=1.77x+0.03, p<0.03, R^2=0.35). Conversely, there was no significant regression between the background and the area of soleus MLR, except for the healthy limb of hemi-

The area of TA MLR was significantly (paired t test, p<0.15) decreased in the affected limb with respect to the healthy limb.

A significant positive relation between background EMG activity of soleus muscle and area of the SLR and MLR was found in normal subjects. This was true particularly when soleus responses with respect to soleus background were considered: soleus SLR (y=0.32x+0.20, p=0.001, R^2=0.22), soleus MLR (y=0.42x+0.13, p<0.003, R^2=0.20). In patients, despite the large variability in the responses, the regression between the relevant background and area of the soleus SLR was maintained and reached significance in paraparetic patients (y=3.80x–0.71, p<0.0001, R^2=0.75) and the affected leg of hemiparetic patients (y=1.77x+0.03, p<0.03, R^2=0.35). Conversely, there was no significant regression between the background and the area of soleus MLR, except for the healthy limb of hemi-

Discussion

PATIENTS WITH ALS AND PARAPARETIC PATIENTS

The results show that body sway area is little affected in spastic ALS and paraparetic pa-

patients without sensory deficit. The body sway area was not increased in these patients with respect to normal subjects, under either EO or EC conditions.

No changes or a minor lateral shift in the M-L position of the CFP were found in patients with ALS or paraparetic patients. In both groups, the slightly anterior position of the CFP showed that patients maintained a forward inclined position of the body. Changes in the forward or backward leaning of the body modulates the body sway area in normal subjects. However, this forward shift was evidently insufficient in patients with ALS and paraparetic patients to produce any effect on body sway area. If anything, the forward sway was simply the counterpart of the increased

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soleus muscle tone, as the higher the tone of the posterior leg muscles the larger the tolerated body forward inclination: a greater stiffness of the posterior leg muscles is necessary and can be sufficient to counteract the gravity torque under conditions of body forward leaning. In these patients, the increased stiffness may be attributable to passive rather than active mechanisms, as the background soleus EMG was in fact not different from normal.

In most patients with ALS and paraparetic patients, there was increased amplitude of short latency stretch responses. This was not related to any increased level of motor pool drive, because, as discussed earlier, background EMG was normal. The increased excitability of the monosynaptic reflex arc was generalised to both extensor and flexor muscles, so that in several of these patients a sizeable SLR was also evoked by toe down rotation in the stretched TA. Therefore, the abnormal excitability of the short latency stretch reflex of leg muscles can fit well with normal body sway. This was true also for the abnormal clinical findings such as increased muscle tone and tendon reflexes, decreased muscle strength, and abnormal plantar response. It seems then that spasticity and some of its major sequelae do not lead to poor control of quiet upright stance. The medium latency response, the size of which is an indication of the excitability of the pathway originating in the spindle secondary afferents, was present in many of these patients both on soleus and TA muscles and was, on average, of normal amplitude or diminished.

HEMIPARETIC PATIENTS

At variance with patients with ALS and paraparetic patients, hemiparetic patients showed significantly larger body sway values under both EO and EC conditions. At variance with previous reports, the increase in body sway was not connected to the side (right or left) or the main localisation (cortical or subcortical) of the lesion. This discrepant finding might be explained by the exclusion of patients with sensory deficits from our study and by the absence of lesions in the right posterior parietal cortex, known to be involved in the processing of internal spatial representation. In our hemiparetic patients, sway increase was accompanied by a significant forward shift of CFP, greater than in normal subjects but similar to that of paraparetic patients. However, as shown for patients with ALS and paraparetic patients, the occurrence of either spasticity or forward shift of the CFP cannot explain an increase of body sway area. At variance with the other patients, hemiparetic patients showed a lateral shift of CFP, a sign of the body weight being unevenly distributed between the lower limbs. In normal subjects, however, voluntary displacement of the body, such as to shift the CFP to the same extent as in hemiparetic patients, resulted in a much lighter increase in body body sway area (unpublished observation). The idea that the increase in body sway area found in hemiparetic patients is connected with the eccentric position of the CFP is further weakened by the absence of a relation between sway area and CFP shift within the group, and by a normal body sway area in those patients with ALS and paraparetic patients whose CFP was shifted laterally to the same extent as in hemiparetic patients. In conclusion, even in the hemiparetic patients, the increased body sway area cannot be solely explained by their faulty posture, although it is conceivable that stance control may be partly worsened by the shift of the body weight toward the healthy limb.

The pattern of EMG reflex responses to postural perturbations in the affected leg of hemiparetic patients was unlike that of the others. The short latency response to stretch was increased, but not to any greater degree than in the other spastic patients. Conversely, the medium latency responses of soleus and TA were reduced, in the affected leg, more than in the other groups. The responses to stretch, which are mediated by the spindle group II afferent fibres, are evidently subjected in hemiparesis to a different descending control from that acting on the short latency response. This notion is strengthened by the finding of no relation between background soleus EMG and amplitude of soleus MLR, whereas a positive relation between these two variables is present in normal subjects and in the healthy limb of the hemiparetic patients. One important source of increased sway in hemiparetic patients can therefore be the decreased modulation in excitability of this response to stretch in the affected limb. There are in fact suggestions that it is this medium latency response, rather than the monosynaptic reflex, that plays a part in the reflex control of quiet stance.

Conclusion

Since neither body attitude, nor paresis or monosynaptic reflex hyperexcitability seem to affect body sway, it can be hypothesised that decreased muscle force or abnormal processing of the input from primary spindle endings or foot sole cutaneous receptors are not paramount in the control of equilibrium during quiet upright stance. Conversely, although no direct information is given by the experiments, the present findings are in favour of a role of the afferent input from spindle secondary endings in the reflex control of equilibrium. In fact, where the normal modulation of excitability of the reflex pathway fed by spindle group II afferent fibres is hardly affected, as in patients with ALS and paraparetic patients, stance stability is within normal limits; on the contrary, in hemiplegia the diminished medium latency
response is accompanied by increased body sway. Velocity sensitive spindle primaries would provide a less important input to the nervous system than the length sensitive spindle secondaries, as during quiet stance very slow body movements occur.\textsuperscript{10, 11} Under this condition, the input from the secondaries should suffice to enable the nervous system to detect low frequency displacements of the body\textsuperscript{12} and produce appropriate changes in muscle tone to counteract the perturbations of balance.\textsuperscript{13} This interpretation is further supported by our recent findings that postural control during quiet stance of patients with peripheral neuropathy\textsuperscript{14} is negligibly affected by loss of group II afferent fibres whereas it is so when group II spindle afferent fibres are also involved by the disease.

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