A strategy for gait initiation in patients with vascular higher-level gait disorders.

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Introduction

Higher-level gait disorders (HLGDs) result from the selection of inappropriate locomotor and postural responses by the highest sensorimotor systems, resulting in impairment in the planning and organisation of gait (Nutt et al 1993). There are clinical differences in gait initiation between patients with vascular higher-level gait disorders; some patients experience gait ignition failure (GIF), while others appear to have no difficulty in initiating gait (Nutt et al 1993). It is not known what proportion of patients with HLGDs have some degree of gait initiation difficulty, nor are the precise nature of these impairments and the strategies used to overcome them fully understood. Normal gait initiation in the elderly is similar to that of young adults and is characterised by an initial pattern of bilateral medial gastrocnemius inactivity, immediately followed by a burst of tibialis anterior activity. This muscle activity produces stereotypical patterns of COM and COP displacement which release the body from its balanced position and produce movement in which lateral balance and forward propulsion are combined in a smooth diagonal motion (Elble 1994).

Methods

Data were collected from seven patients, whose gait patterns encompassed a range of HLGDs from severe gait ignition failure to clinically near-normal gait and gait initiation (Table 1). Subjects performed at least ten trials of gait initiation at self-selected normal speed. Kinetic data were not available from one patient (TM) due to failure of the forceplate data collection. Centre of mass (COM) displacement was measured using a six-camera 3D kinematic system, centre of pressure (COP) was collected using a forceplate. The means (SD) of each patient's variables are compared with normal reference ranges previously defined from 21 healthy elderly people.

<table>
<thead>
<tr>
<th>Patients’ descriptions of gait</th>
<th>Patients’ descriptions of falls</th>
<th>Patients’ descriptions of normal activity level</th>
<th>Clinical examination/description of gait</th>
</tr>
</thead>
<tbody>
<tr>
<td>walking</td>
<td>falls</td>
<td>normal activity level</td>
<td>GIF</td>
</tr>
<tr>
<td>AL</td>
<td>Feels unsteady, difficulty trying to avoid obstacles</td>
<td>None for 2½ years</td>
<td>Mobile around house and to shop/club across road. Uses stick</td>
</tr>
<tr>
<td>JO</td>
<td>Difficulty with balance and getting started. Occasional L knee pain</td>
<td>Yes, none in last month</td>
<td>Mobile in house only. Uses stick</td>
</tr>
<tr>
<td>AY</td>
<td>Nil particularly</td>
<td>1 a month</td>
<td>Mobile around flat, stairs, short distances outside. Uses stick.</td>
</tr>
<tr>
<td>AH</td>
<td>Poor balance. Gets short of breath</td>
<td>1 last month</td>
<td>Furniture walking in house. Manages stairs. Nil outside</td>
</tr>
<tr>
<td>TM</td>
<td>Difficult to get going, balance very poor</td>
<td>Fear of falls</td>
<td>Around house with rollator or furniture. Outside with help</td>
</tr>
<tr>
<td>RE</td>
<td>Occasional backache, otherwise nil particularly</td>
<td>infrequent</td>
<td>Moderate ADL, inside and out. No walking aid.</td>
</tr>
<tr>
<td>KM</td>
<td>Difficulty initiating stride. Some pain R. great toe.</td>
<td>Nil recently</td>
<td>Mobile around house with furniture or a stick. Nil outside (wheelchair)</td>
</tr>
</tbody>
</table>

Table 1 Initial patient assessment – characteristics of gait (n=7). The patients perception of their gait difficulty, falling and normal activity level, plus a clinical gait assessment. GIF = gait ignition failure (start hesitation freezing)

Gait initiation is divided into two phases, the preparatory phase from onset of COP displacement until swing toe-off (SW TO), and the stepping phase from SW TO to stance toe-off (ST TO). The preparatory phase is
subdivided into a release phase, from onset until the point of maximum posterolateral displacement of the COP (maxCOP) and an unload phase from maxCOP to SW TO. Stepping is subdivided into single and double support phases (SSP and DSP). Vectors connecting the COP and COM are linearly related to the acceleration of the COM (Jian et al 1993). The magnitude of the anteroposterior (A/P) vector between the COM and COP is calculated, and described as the anteroposterior COP/COM moment arm.

**Results and Discussion**

The initial posterior displacements of the COP are less than normal in release while the lateral COP displacements towards the swing leg are within normal range (figure 1). Similarly, anterior COM displacement during the unload phase tends to be less than normal, while mediolateral COM displacements are mostly within the normal range (figure 1). The differences between anteroposterior and mediolateral displacement of the COP and COM are similar to those reported by Elble et al (1996). A similar pattern of COP and COM displacement is seen in children of up to six years (Malouin & Richards 2000). They suggest that young children require more walking experience and improved postural stability to achieve mature patterns of COP and COM displacement.

In normal elderly subjects the anterior COP/COM moment arm increases steadily from onset (figure 2). This sustained forward acceleration of the COM is delayed in most patient trials until the end of the preparatory phase, as shown by the anterior COP/COM moment arm plots for each patient (figure 3). Four patients delayed anterior COM acceleration in all of their trials, while two patients delayed for most of their trials (90% and 66% of trials). This delay in forward propulsion until after the normal range of lateral COM displacement is completed suggests the adoption of a two-part strategy for gait initiation. The COM is moved laterally to enable the lateral postural adjustments seen in normal gait initiation to be completed before forward propulsion of the COM is started. This strategy prioritises frontal plane balance/postural control over propulsion. However, it seems unlikely that this strategy is simply compensation for a balance deficit, as it is used by patients who have good standing and walking balance, as well as those with balance impairment. It may be due to a difficulty in selectively controlling the

![Figure 1](image1.png)

**Figure 1** Mean displacements of the COP and COM during gait initiation for individual patients. The release phase is from onset to the initial maximum posterolateral displacement of the COP (maxCOP). The unload phase is from maxCOP to SW TO. Black error bars show the normal reference ranges, calculated as mean ± 2SD from 21 normal elderly people. Positive values are anterior or towards the stance leg.

![Figure 2](image2.png)

**Figure 2** Mean ± 1SD anteroposterior COP/COM moment arm, during gait initiation for normal elderly people (n = 18). Vertical red lines are at SW HO, SW TO and SW HC. 0 – 100% = the preparatory phase and 101 to 200% = the stepping phase of gait initiation.
inter-segmental postural adjustments, especially around the pelvis, that are required to achieve the transition onto one leg, problems which are commonly seen in patients with neurological conditions such as stroke (Carr & Shepherd 1998).

![Figure 3](image-url)

**Figure 3** Mean ± 1SD anteroposterior COP/COM moment arm, during gait initiation for all trials (n = 6 - 11) for each individual patient (n = 6). Vertical red lines are at SW HO, SW TO and SW HC. The mean % duration of the preparatory phase varies between patients, within an overall gait initiation duration expressed as 0 - 200%.

**References**
Elble R. et al. Movement Disorders, 9,139-146, 1994
Jian Y. et al. Gait & Posture, 1,9-22, 1993
Malouin F. Richards CL. Gait & Posture, 11, 239-253 2000

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