Marked impairments in the bilateral coordination of gait in post-stroke patients

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REFERENCES


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INTRODUCTION
One of the unique aspects of gait is the bilateral coordination required to control left and right foot timing. A new metric, the phase coordination index (PCI), was recently developed in order to quantify the bilateral coordination of stepping during functional forward walking [1]. The metric focuses on the phase of the gait cycle of one leg with respect to the other. The objective of the present work was to study if patients with an asymmetric cerebral disease, stroke, would have deficiencies in bilateral coordination of the gait that could be quantified using the PCI. Further, whereas the original development of the PCI was based on data from footswitches, here we adapted it to accelerometer-based measures [2].

METHODS
A tri-axial piezo-resistive accelerometer (DynaPort, McRoberts, The Netherlands) fixed around the waist, was used to measure gait parameters during straight line walking (~120 m) of twelve healthy older adults (mean age: 55.1 ± 1.8 yrs) and twelve patients with hemiplegia (mean age: 56.1 ± 2.2). Bilateral coordination of gait was assessed by examining the phase between the step of the left and right limbs. Specifically we quantified the stride duration of one foot as a gait cycle or 360°, determined the relative timing of contra-lateral heel-strikes, and defined this as the phase, φ, (ideally, φ=180° for every step). The sum of the coefficient of variation of φ (φ_CV) and the mean absolute difference between φ and 180° (φ_ABS) was defined as the PCI, representing variability and inaccuracy, respectively, in phase generation. We also quantified gait asymmetry (GA): GA=100%*(ln(RSW/LSW)), where RSW and LSW represent the mean values of the left and right swing time, respectively.

RESULTS
PCI and GA were larger in the stroke patients, as compared to age-matched controls (Table 1). PCI was strongly correlated with GA in the stroke patients (R2=0.83, p<0.001) as compared with the correlation seen in elderly subjects (R2=0.38, p=0.03). No significant correlations were seen in both groups between GA or PCI and gait speed. Stepping phase values are plotted for a stroke patient (left panel) and a healthy age-matched adult (right panel). For the healthy adult, stepping phases are scattered close to the 180° line and the mean value of φ was 182.3°. Values of φ_ABS and φ_CV were 4.6° and 2.9°, respectively. Stepping phase values are dispersed further and farther from the 180° line in the case of the stroke patient. The mean φ value was 211.3°. Values of φ_ABS and φ_CV were 33.5° and 9.6%, respectively (figure 1). Asymmetry of gait was significantly higher for the stroke patients compared to the healthy controls. Figure 2 illustrates this point.

CONCLUSIONS
As anticipated, the PCI is very different in post-stroke patients compared to age-matched controls. These findings further demonstrate that this index may be used as a sensitive measure of the bilateral coordination required to successfully ambulate. Perhaps it may also help to quantify stroke severity and the response to therapeutic interventions.

Table 1: Gait and bilateral coordination parameters. Means ± SE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stroke patients</th>
<th>Healthy Elderly</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI (%)</td>
<td>19.5 ± 2.3</td>
<td>6.2 ± 1.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GA (%)</td>
<td>26.3 ± 5.6</td>
<td>5.6 ± 1.2</td>
<td>0.001</td>
</tr>
<tr>
<td>Gait Speed (m/s)</td>
<td>1.1 ± 0.1</td>
<td>1.7 ± 0.1</td>
<td>0.001</td>
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</tbody>
</table>

* t-test

Figure 1 Asymmetry and PCI for a stroke subject (left) and a healthy control (right).

Figure 2 Swing time duration for a stroke subject (left) and a healthy control (right).

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