SHORT REPORT

Incremental limb hypometria

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To find out if patients with right hemisphere strokes (RHD) demonstrate a form of progressive or incremental limb hypometria (ILH), 11 RHD patients and eight matched controls were tested by having them draw a series of horizontal lines while blindfolded. Unlike controls, six RHD patients displayed an incremental decrease in the length of lines they drew, a sign of ILH. ILH might be a common source of disability and hinder rehabilitation efforts.

The term "motor impersistence" was coined by C Miller Fisher to describe patients who show an inability to sustain postures for more than a few seconds.[1] All of Fisher's patients had left hemiplegia, and thus he suggested that damage to the right hemisphere induces this disorder. Subsequent studies supported Miller's observations, demonstrating a strong relationship with right hemisphere injury.[2] Although these initial reports primarily investigated the ability of patients to maintain extraocular, facial, oropharyngeal, and respiratory postures that are all bilaterally innervated, subsequent reports suggested that motor impersistence could be observed in a limb.[3]

Patients with right hemisphere strokes and especially those with neglect generally have a poor response to rehabilitation.[4] In addition, several studies have demonstrated that family burden is greater and functional outcome worse for patients with right hemispheric stroke and hemispatial neglect than would be predicted by just the severity of sensory motor deficits.[5–7] Although these studies suggest that hemispatial neglect and anosognosia associated with right hemisphere damage might be causing this disability, demonstrable hemispatial neglect and anosognosia are usually temporary and thus some form of impersistence might account for the poor response to rehabilitation and high caregiver burden associated with right hemisphere injury.

The purpose of this study is to learn if some patients with right hemisphere injury might be initially able to correctly perform an action with their ipsilesional forelimb, but with repeated trials have a progressive decrease in the action magnitude and are, therefore, unable to properly complete the task. We call this phenomenon incremental limb hypometria (ILH) and our goal was to learn if patients with right hemispheric injury demonstrate ILH with their ipsilesional (right) forelimb. To assess these patients for ILH, we had blindfolded subjects draw with a pen, on a sheet of paper, 10 horizontal lines of a given length, using back and forth (rightward and leftward) continuous movements. If subjects have ILH, they might terminate their movements before they reach the target length of movement. Thus, on tasks that require repeated movements of the same magnitude, ILH is defined as an incremental reduction of movement length during the course of repeated movements.

MATERIALS AND METHODS

Participants

The experimental subjects were 11 right handed patients (mean 55.2 (SD 9.2) years old, 7 men; 4 women) with right hemisphere strokes that were confirmed with either MR or CT imaging and eight age matched right handed controls (mean 63.1 (SD 9.4) years old, 3 men; 5 women) who are without neurological disease (table 1). Except for a left hemiparesis the experimental subjects exhibited few other abnormalities. All experimental and control subjects performed normally on the Mini Mental Status Examination (⩾25). Whereas at the time of testing, no subject showed motor impersistence of midline structures, hemispatial neglect, or Parkinsonism, when assessed shortly after the onset of their strokes all the experimental participants demonstrated hemispatial neglect. Informed consent, approved by the local institutional review board, was obtained from all subjects before their enrollment in this project.

Apparatus and procedures

A sheet of paper (215.9×355.6 mm) was placed on a table in front of the subject with its longer side aligned with the subjects' coronal plane. Two 191 mm vertical lines were printed on the test sheets. Each of these marker lines was 38.1 mm from the outer margins and each marker line ended 12.7 mm from the upper and lower margins of the test sheets. Thus, the distance between these two marker lines was 279.4 mm. The top or bottom ends of these printed lines served as starting points for drawing (four different starting points). The subjects were asked to draw horizontal lines on the sheet with a black felt pen using his or her right hand. They were instructed to make their line go from one marker line to the other and then to move a short distance vertically (up or down, depending on the starting point) and move to the opposite line and to repeat this process until they had drawn 10 lines. Before the test trials each subject performed practice trials with his or her eyes open. The subjects were encouraged to fully extend their drawn lines between the two lateral markers. To avoid visual feedback, the subjects were blindfolded during the experimental trials. In total, each subject underwent 20 trials that were evenly allocated to the four starting points. The order of starting points was counterbalanced across subjects.

RESULTS

All experimental and control subjects successfully drew 10 horizontal lines without decreasing the lengths with their eyes open. In the blindfolded condition, however, six out of 11 patients exhibited gradual or *incremental* decreases in the length of horizontal lines (fig 1). In contrast, only one control subject exhibited a moderate decrease in the length of horizontal lines. This decrease in line length, when present, was most severe between the first and fifth lines, but was negligible thereafter. The rate of change in the length of

Abbreviation: ILH, incremental limb hypometria.

Table 1 Participants

	Age	Sex	Site of injury	ILH	Months after stroke
Patient 1	43	F	Large right middle cerebral artery region	+	55
Patient 2	52	F	Right temporal pole, insula, basal forebrain, putamen, caudate	+	9
Patient 3	46	M	Right subcortical white matter, putamen, caudate	+	11
Patient 4	63	F	Right frontal, parietal and insular cortices, putamen	+	35
Patient 5	45	M	Right temporal, parietal and occipital cortices, putamen, caudate	+	41
Patient 6	54	M	Right thalamic hemorrhage	+	8
Patient 7	61	M	Right subcortical, anterior putamen	−	35
Patient 8	74	M	Right occipital and inferior mesial temporal lobe	−	4
Patient 9	60	M	Large right middle cerebral artery region	−	51
Patient 10	51	M	Right frontal lobe and insular infarction, sparing most of the basal ganglia and parietal lobe	−	19
Patient 11	59	F	Lacuna in right periventricular white matter	−	46
Control 1	82	M		−	
Control 2	72	F		−	
Control 3	61	M		−	
Control 4	61	F		−	
Control 5	61	F		Mild	
Control 6	56	M		−	
Control 7	53	F		Mild	
Control 8	59	M		−	

horizontal lines drawn by patients during the first five lines was mean –8.07 (SD 9.33) mm/line. This was significantly different from the change demonstrated by the control subjects (mean 1.92 (SD 5.59) mm/line) ($t = 2.9$, $p = 0.01$). During the second five lines the rate of change of the line lengths for the patients (2.38 (SD 3.01) mm/line) was not significantly different than that of the controls (mean 1.11 (SD 2.71) mm/line) ($t = 0.96$, $p = 0.35$). When the data were normalised, by basing the subjects' performance on the first drawn line, patients' drawn line lengths from the second through the tenth line were all significantly less than those of the controls ($t>2.23$, $p<0.038$) (fig 2). In both the experimental and control subject groups, there was no evidence for a directional hypometria, such that the reduction of length of the lines drawn in one direction (for example, leftwards) did not differ from the reduction of length of lines drawn in the opposite direction (experimental subjects $p>0.18$; control subjects $p>0.08$, two tailed paired t test).

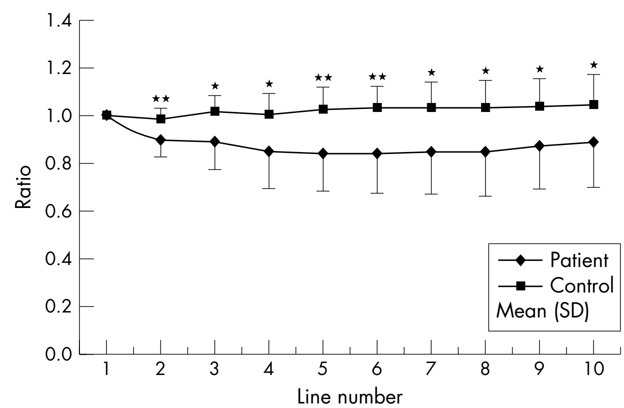

Figure 2 Normalised lengths of horizontal lines drawn by control and experimental subjects (*p<0.05; **p<0.01).

DISCUSSION

These results suggest that ipsilesional ILH does exist as a distinct clinical entity. Although we found that upper limb ILH was associated with right hemispheric injury, we did not test left hemisphere damaged subjects and therefore we cannot be certain that this is a lateralised phenomenon. In addition, because five out of 11 patients did not show ILH, our patient population appears to be heterogeneous. It would be unlikely that this heterogeneity is related to demographic factors or the presence of dementia. The most likely explanation of this heterogeneity is lesion location. To resolve this dilemma, however, further studies with a large number of subjects would be necessary.

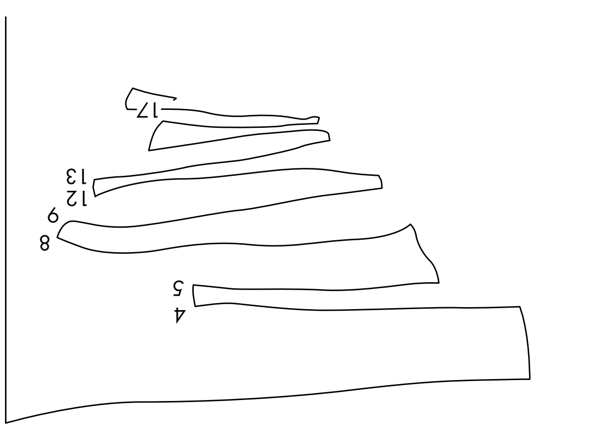

Figure 1 Representative drawing by an experimental subject.

The neuropsychological mechanism of ILH is not known. Several investigators have reported that with unilateral hemispheric strokes patients can demonstrate both a proximal and distal weakness and a reduction of the magnitude of movement of the ipsilateral limb.[7–9] Patients with hemispatial neglect can demonstrate a directional hypokinesia[10] and we thought that this might be in part responsible for the hypometria, but there was no evidence that the hypometria was directional and when tested no patient had neglect. Patients with Parkinson's disease often show progressive micrographia. Hence, Parkinson's disease might also be associated with ILH. Our patients, however, did not show evidence of Parkinson's disease and had no difficulty drawing 10 horizontal lines that were of full length with their eyes open. Therefore, our subjects are unlike parkinsonian patients who have micrographia even with their eyes open.

Although we suspect that IHL is a form of motor limb impersistence, the cause of this form of impersistence is unclear. Impersistence is often associated with other signs of

abulia; a loss of the will to act or the reduction of goal oriented behaviour.[10] Alternatively, it is possible that while performing this task the subjects develop a proprioceptive and/or a visuospatial representation of the distance that needs to be traveled. Attention can influence estimates of magnitude, such that objects which are strongly attended might appear to be larger but those less attended appear smaller than the actual size.[11] Perhaps, the subjects that demonstrated IHL rapidly attenuated their attention (habituated) to their mental map of the distance between the two vertical lines and thus with repeated trials the distance portrayed in this map became progressively shorter. Another possible mechanism is progressive impairment in kinesthetic feedback that induced an impaired estimate of distance traveled,[12 13] but the reason why this kinesthetic feedback would be progressively altered is unclear.

It has been reported that with right hemisphere strokes, a right hand functional impairment can be due to cognitive deficits, especially visuospatial deficits[14] as well as elements of the neglect syndrome. In these patients with right hemisphere strokes and left sided weakness, a progressive impersistence of the non-paretic right arm can be a serious obstacle to independent living and rehabilitation. Thus, future studies need to be focused on the mechanisms of this disorder and its treatment.

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