Disruption of sitting balance after stroke: influence of spoken output

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SHORT REPORT

Disruption of sitting balance after stroke: influence of spoken output

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Objectives: To identify the extent of dual task interference between cognitive and motor tasks, (cognitive motor interference (CMI)) in sitting balance during recovery from stroke; to compare CMI in sitting balance between stroke and non-stroke groups; and to record any changes to CMI during sitting that correlate with functional recovery.
Method: 36 patients from stroke rehabilitation settings in three NHS trusts. Healthy control group: 21 older volunteers. Measures of seated postural sway were taken in unsupported sitting positions, alone, or concurrently with either a repetitive utterance task or an oral word category generation task. Outcome measures were variability of sway area, path length of sway, and the number of valid words generated.
Results: Stroke patients were generally less stable than controls during unsupported sitting tasks. They showed greater sway during repetitive speech compared with quiet sitting, but did not show increased instability to posture between repetitive speech and word category generation. When compared with controls, stroke patients experienced greater dual task interferences during repetitive utterance but not during word generation. Sway during repetitive speech was negatively correlated with concurrent function on the Barthel ADL index.
Conclusions: The stroke patients showed postural instability and poor word generation skills. The results of this study show that the effort of verbal utterances alone was sufficient to disturb postural control early after stroke, and the extent of this instability correlated with concomitant Barthel ADL function.

Stroke represents an important source of disability among older adults.[1] Symptoms often include disruption of movement control and cognitive processing. Multidisciplinary assessment and rehabilitation lead to reduction in disability,[2 3] but the extent to which motor and cognitive components of functional ability impact on one another and affect responsiveness to rehabilitation is not yet understood. Motor control is traditionally assumed to be largely automatic during everyday tasks in healthy adults.[4] However, dual task studies of motor function and cognitively demanding activity among older people suggest that these tasks compete for attentional resources, leading to mutual interference with poorer dual task performance of one or both activities.[5–7] Independent control of sitting balance is an important goal of functional recovery after stroke[8] but may be affected by concurrent task demands.

This study investigates task interferences in sitting balance control among patients recovering from stroke compared with older adult controls and examines for a relation with clinical measure of functional recovery, the Barthel ADL index.

METHODS

Participants

Thirty six patients (mean age 61.6, SD 15.9 years) with recorded postural instability after stroke were recruited from inpatient rehabilitation settings on average 69 (SD 50) days after stroke. Patients were included provided they could give informed consent and perform the word generation task. The fatigue impact scale[9] was given at entry (mean 26.9, SD 14.3). Other scores (Barthel ADL index[10] mean 12.9, SD 3.7; short orientation-memory-concentration test[11] 22.1, SD 5.8; star cancellation task[12] 47.3, SD 14.5) were taken from clinical notes. Barthel scores were also collected by telephone one and three months later. Twenty one older adult volunteers (mean age 71.0, SD 7.5years) with no history of neurological illness and MMSE[13] score at least 24/30 formed a control group. The study met the criteria of the local research ethics committees and all participants gave informed consent.

Study design

Sitting balance was measured using a modified Balance Performance Monitor, placed on a supporting seat on an adjustable plinth. Participants sat with their feet on the floor, with knees and hips at 90 degrees. Cognitive performance was measured using word category generation.[14] Participants were given one of four target categories and asked to supply exemplars for one minute. Score was number of valid English words generated. A second oral condition—repeating the sound "ba" for about eight seconds at a rate of one per second—was included to assess whether spoken output influenced postural control in the absence of cognitive demand. They were given a signal to stop for eight seconds then the cycle was repeated.

Procedure

During unsupported sitting, participants sat upright, as still as possible, and carried out three tasks: sitting still only; repetitive utterance ("ba"); and category word generation. During "supported" word generation trials the participants rested back into the supporting seat. The four trials were repeated twice in separate testing blocks. Order of task presentation and target category were systematically varied across participants. Each trial lasted for one minute. No patient failed to complete a trial in block 1 but some were too fatigued to attempt all trials in block 2.

RESULTS

Postural control

Two measures of seated postural control are reported: the average change in position from the initial starting point (root mean squared variability of sway) calculated the area of sway movement, and the cumulative movement from start position (path length) calculated how much movement occurred within this area. A 2 (group: stroke, control) ×3 (unsupported sitting tasks: sitting still, repetitive utterance, word generation) ×2 (testing block: block 1, block 2) repeated measures analyses of variance was performed for each posture measure.

Table 1 Results of sitting balance control and word generation

	Postural control						Word generation	
	Path length (cm)			Variability (RMS cm)			Number of valid words	
Group	Still	Words	Ba	Still	Words	Ba	Supported	Unsupported
Stroke	108.2 (28.7)	132.9 (42.6)	128.2 (42.3)	0.51 (0.35)	0.67 (0.39)	0.61 (0.47)	14.8 (7.4)	13.8 (6.4)
Control	86.3 (19.3)	104.0 (25.5)	86.2 (23.2)	0.37 (0.12)	0.79 (0.39)	0.40 (0.17)	26.4 (7.0)	24.1 (5.9)

Sitting balance includes path length, a measure of the total additive movement during each trial (cm), and variability of sway, which is calculated as the root mean square (RMS) in cm of movement from the initial start point, mapping the total area of movement. Word generation shows the total number of valid English words generated during each one minute trial. All data are averages of testing blocks 1 and 2, data in parentheses shows the standard deviation of these results.

Variability of sway

There was no main effect of group but there was a task by group interaction $F(2, 110) = 7.49$, $p<0.01$. Post hoc analyses showed that for stroke patients, variability increased during word generation compared with still sitting but not repetitive utterance ($p<0.01$). The control group showed greater sway variability during word generation than repetitive utterance ($p<0.01$). There was an effect of testing block for both groups, with increased variability on both axes from block 1 to block 2 for each task condition, $F(1, 55) = 22.57$, $p>0.001$, which may represent fatigue.

Path length

This was significantly greater for the stroke group than for controls, $F(1, 55) = 13.90$, $p>0.001$ and there were differential effects of task demand, $F(2, 110) = 4.24$, $p>0.05$. For the stroke group path length was longer during word generation than sitting still ($p<0.001$) and during repetitive utterance than sitting still ($p<0.001$) but there were no differences between repetitive utterance and word generation. For controls, path length increased during word generation compared with sitting still ($p<0.01$) and to repetitive utterance ($p<0.01$) but there were no differences between repetitive utterance and sitting still. Path length did not differ between blocks for either group.

Word category generation

Repeated measures analysis of variance examined the effect of sitting support (supported, unsupported) and testing block (block 1, block 2) on number of words generated across groups. The control group generated more words than the stroke group, $F(1, 51) = 30.46$, $p<0.001$. All participants generated more words during supported than unsupported sitting, $F(1, 51) = 15.70$, $p<0.001$; but there were no differences between blocks.

Proportional dual task costs (pDTC)

The proportional dual task costs (pDTC) between sitting still (baseline) and the unsupported spoken tasks (dual tasks) were calculated. For variability of sway, pDTC during word generation was greater than for repetitive utterance, $F(1, 55) = 40.48$, $p>0.001$ for both groups. There was no group difference during the repetitive utterance task, but controls showed greater pDTC than the stroke group ($p<0.05$) during word generation. For path length, pDTC was greater during word generation than repetitive utterance, $F(1, 55) = 20.69$, $p<0.001$ and greater for the stroke group than controls during repetitive utterance ($p<0.05$) but did not differ significantly between groups during word generation. There was no evidence of increased pDTC between block 1 and block 2 for any measure (fig 1).

Association with ADL

For stroke patients, variability of sway during repetitive utterance correlated significantly with Barthel ADL index at testing ($r = -0.41$), and at one ($r = -0.37$) and three ($r = -0.43$) months later, with less variability being associated with a higher ADL score. Variability of sway during word generation only correlated significantly with ADL at three months ($r = -0.42$). No other correlations were significant.

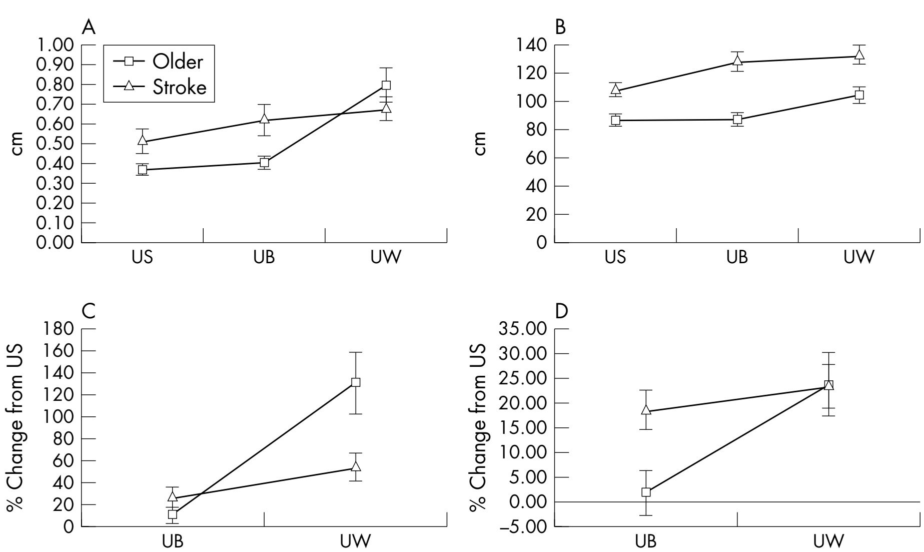

Figure 1 Changes to sitting balance stability across sitting conditions. Graph A shows the variability of sway from starting position and graph B shows the average movement measured as path length. Both graphs show the average for each sitting condition; still sitting (US), repetitive utterance (UB), and unsupported word generation (UW). Graphs C and D show the per cent movement change during repetitive speech and word generation compared with sitting still. Graph C shows the difference from baseline conditions measured as proportional dual task cost (pDTC) for variability; graph D shows pDTC for path length. All graphs show movement data for both the stroke and the control groups. The error bars presented in each graph represent SE mean.

DISCUSSION

Stroke patients were generally less stable than controls; postural instability increased significantly during repetitive utterance compared with sitting still, but did not increase further when generating words. The controls showed increased instability during word generation but little effect of repetitive utterance. Spoken output may, therefore, have an important disruptive influence on posture control after stroke, independent of content. Although thinking plus speech did not produce additional decrements for patients, they generated fewer words than controls. This may account for the lack of additional interference from word generation.

Thoracic movements entailed in spoken output may directly disrupt sitting balance[15] but there was no evidence to show that sway increased proportionally with number of spoken outputs. Our results suggest a model of attentional interference: any task carried out during unsupported sitting will compete for limited attention resources and result in postural interference.[14] Repetitive utterance normally requires fewer cognitive resources than word generation, although sustained attention is necessary for both tasks to maintain an output stream. Competition between the tasks may have overloaded patients' processing resources so they neglected word generation in favour of maintaining postural control. A limitation of this study, however, was that no independent measure of vocabulary ability was available for patients.

Significant negative correlations between sway variability and Barthel ADL scores show that patients with higher Barthel scores had less variable sitting balance than patients with lower scores. This association remained evident three months later, when patients with greater sway variability during repetitive speech and word generation at test still recorded lower Barthel scores. Although these correlations do not predict extent of functional recovery, they do show a relation between functional recovery and dual task ability. Fatigue is a significant problem for stroke patients,[16] especially in early stages of recovery and can affect participation in rehabilitative activities. All patients showed greater variability in sitting position during block 2 compared with block 1, which may indicate fatigue. As self reported score on the fatigue impact scale did not reflect the task associated fatigue seen in patients between blocks 1 and 2 of this study, measures of unsupported sitting may provide a better objective measure of fatigue during stroke recovery and may be a suitable tool for measuring recovery of stamina after stroke. We also found a fatigue effect for the controls, which may show the resource demands of this simple task, reinforcing previous cognitive and posture interference studies.[17]

This study suggests that tasks of low cognitive effort may interfere with posture control after stroke, a finding that has implications for early rehabilitation activities. Further investigations that systematically assess the relative influence of concurrent task demands on motor activity are essential for planning effective rehabilitative motor control tasks for stroke recovery.

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