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Dual-task effects of talking while walking on velocity and balance following a stroke

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Abstract

Background: therapists and nurses often use verbal instruction in the rehabilitation of mobility following stroke. This study aimed to determine whether performing a verbal cognitive task while walking adversely affected patients' balance and velocity.

Methods: there were two counterbalanced conditions: walking only and walking and concurrent cognitive activity. The cognitive activity used was to give one of two verbal responses to two verbal stimuli. An electronic GaitMat measured gait velocity and balance (double support time as a percentage of stride time).

Results: 11 people with stroke participated in the study (five women and six men, mean age 72 years, SD 9). They were on average 120 (SD 48) days post-stroke. Velocity decreased ($P = 0.017$) and double-support time as a percentage of stride time increased ($P = 0.010$) when the cognitive activity was added to the test.

Conclusions: performing a verbal cognitive task while walking adversely affected stroke patients' balance and gait velocity. Susceptibility to disruption varied within the patient group, suggesting clinical heterogeneity. Further research is required before changes to clinical practice are justified.

Keywords: *cognition, gait, rehabilitation, stroke*

Introduction

Relearning to walk independently is a common rehabilitation goal of stroke survivors.

Movement involves not only motor skills, but is also reliant on sensory and cognitive systems [1]. Therapists rehabilitating patient mobility following stroke need to take account of the evidence that cognitive resources are drawn upon when walking [2] and that this requirement increases with age [3]. There is also evidence that some older people stop walking when they talk and that this phenomenon predicts susceptibility to falling [4].

Therapy should also be informed by a consideration of what happens to certain aspects of walking, namely velocity and balance, when additional cognitive demands are placed on patients as they walk. Many activities in everyday life require the person to complete several tasks concurrently (e.g. walking and talking). When the processing requirements of two tasks exceed the capacity of the cognitive system, interference across tasks occurs and one or both of the tasks will be impaired [5]. However, another school of thought argues that impaired functioning results from two tasks competing for the same resources because they have similar processing demands.

In everyday practice, therapists and nurses converse with stroke patients during rehabilitation sessions: for example, offering explicit verbal instruction and feedback on progress, or providing reassurance to reduce anxiety. However, the processing involved in verbal interactions when walking could have adverse effects on a stroke patient's velocity or balance. Previous research has failed to demonstrate adverse effects on gait speed or step length [2] or on balance control [6] in healthy young and older subjects. In the present study, we aimed to investigate whether 'talking while walking' adversely affected stroke patients' velocity and balance control.

Hypotheses

1. Concurrent verbal activity would impair walking as reflected in (i) decreased velocity and (ii) increased braking double-support time (DST) as a percentage of stride time (DST%).
2. An increase in DST% would suggest an adaptation to the threat of imbalance, as participants would be spending more time in this more stable phase of walking.

Materials and methods

Participant selection

Inclusion criteria were: consecutive admission to hospital following a stroke in the previous 7 months, discharge to their own or family home, age $\geqslant 60$ years; ability to walk 10 m unaided or with a stick, sufficient hearing and vision to complete the required tasks, and ability to understand verbal instruction, give informed consent and give accurate 'yes'/'no' responses. Excluded from the study were those discharged to nursing or residential homes as they were unlikely to meet the inclusion criteria. We excluded people using walking frames due to the constraints of GaitMatII recording.

The study was approved by the local research ethics committee and all participants gave informed written consent.

Procedure

R. W. conducted screening assessments of participants' auditory comprehension, and the accuracy of their 'yes'/'no' verbal responses. We assessed eligible participants using standardized clinical measures of balance, working memory span and emotional state—Berg balance scale [7], WAIS-R digit span [8] and Wimbledon self-report scale (WSRS) [9] respectively.

Following a practice trial, participants completed three walks in each of two conditions:

1. Single-task, walk only. Velocity and DST% were recorded as participants walked the 8 m walkway. DST is when both feet are in contact with the ground. 'Braking' support time refers to the first of two periods of DST within a stride (the second period being propulsive DST). DST% was used as an indicator of balance, as it measures the proportion of time participants spend in the more stable double-support phase (i.e. two feet on the ground). An increase in the duration of DST as a percentage of stride time may be a useful indication of imbalance [10–12].
2. Dual-task cognitive walk. Participants performed a verbal cognitive task repeatedly during the 8 m walk. Participants gave a verbal response on hearing the auditory verbal stimulus. Participants responded by saying 'yes' when they heard the word 'red' and 'no' when they heard the word 'blue'. No words other than 'red' and 'blue' were used.

Participants knew on which walks they would hear words and on which walks they would not, as they were given instructions before the start of each walk. The conditions were counterbalanced to control for order effects from practice or fatigue. Data collection began after the participants' first three steps to allow for gait initiation to take place [13]. A researcher walked just behind the participant to ensure safety and reduce anxiety. Rest breaks were taken as required. To avoid biasing either speed of walk or cognitive response, no instructions on speed were given. Participants were given standard instructions to start walking after hearing 'Ready, go', and to keep walking until asked to stop.

Apparatus

A cassette recorder and tapes presented the verbal auditory stimuli in a uniform manner to all participants in all conditions. Each of the two stimuli was presented at 3-s intervals in random order to prevent anticipation. Participants heard the stimuli through a lightweight headset worn during both conditions but only active during the dual-task cognitive walk.

An 8-m walkway, containing a 3.87-m instrumented section (GaitMatII), recorded velocity and DST%. The GaitMatII consists of 40 rows of 256 pressure-sensitive switches that close on foot contact and open on loss of contact. The maximum potential spatial accuracy is ± 15 mm as this is the actual spacing of the transducers on the mat. Data were sampled at 200 Hz, giving a temporal accuracy of ± 5 ms.

Results

Participants

Eighteen of the 30 people considered for the study refused or did not reply to two written invitations to participate. Data from a further patient could not be reliably obtained from the GaitMatII because of a severe shuffling gait. This resulted in 11 participants, mean age 72 years (SD 9). The mean number of days post-stroke was 120 (SD 48). The diagnosis of ischaemic stroke was confirmed by clinical examination and in a head computed tomography scan. Abnormal performance was indicated by low scores on the Berg ($<45/56$) and

Table 1. Demographic and clinical details for the 11 participating stroke patients

Patient	Age/sex	Lesion site[a]	Scale score: Berg balance[b]	Digit span[c]	WSRS[d]
1	86/F	Right	50	9	2
2	77/M	Right	44	8	0
3	85/M	n/a	41	7	4
4	64/F	n/a	56	7	1
6	72/F	Left	47	10	2
7	74/M	Left	42	5	0
8	64/M	Left	55	4	0
9	63/M	Right	55	7	0
10	61/M	n/a	42	7	28
11	70/F	Right	55	13	9
12	78/F	Left	37	12	6

[a]On computed tomography: n/a, not available.
[b]Range, 0–56; abnormal performance, <45.
[c]Age-scaled score: range, 1–19; abnormal performance, <7.
[d]Wimbledon self-report scale: range, 0–30; abnormal performance, >7.

digit span (age-scaled score <7/19) scales and high scores (>7/30) on the Wimbledon scale. Demographic details and scale scores are shown in Table 1.

Main analyses

Following tests of normality, we conducted paired *t*-tests to test the two hypotheses.

There was a significant decrease in velocity ($P=0.017$) in the dual-task compared with the single-task condition (see Table 2). There was a significant increase in braking DST% in the dual-task compared with the single-task condition ($P=0.010$).

Changes between the single- and dual-task conditions for each participant are shown in Figures 1 and 2. Despite the significant overall group effect, velocity did not appear to decrease for every participant (see, for example, patient numbers 2 and 6), and DST% did not appear to increase for every participant (see, for example, patient numbers 6 and 11). In fact, velocity increased and DST% decreased for one participant (patient number 9), who, as Table 1 shows, had no obvious impairment of balance, working memory or mood.

Discussion

We found that concurrent verbal cognitive activity during walking decreased velocity and increased DST% in a sample of 11 older participants within 7 months of stroke. In other words, talking while walking slowed participants' walking speed and disrupted their balance. Despite the small sample, the results were statistically significant. Moreover, the magnitude of the adverse effects is likely to have clinical significance. The mean decrease in velocity equates to >4 m/min, a sizeable distance for someone who has difficulty walking. An absolute change of 2 in DST% (from 18.9 to 20.9) is also likely to be clinically significant, as this is on average a 10% increase. It is unlikely that the changes in balance were simply due to the changes in velocity (or *vice versa*). Velocity and DST% appeared independently affected as there was little correlation ($r=-0.25$) between the change in velocity and that in DST%.

Patients with poor balance may use strategies other than increased DST%. For example, patients may increase their width of base of support to decrease the amount of movement of centre of mass necessary to transfer weight from one foot to another. Increased width of base of support may not be evident in the DST% measure. Although the relationship between DST% and width of base of support warrants further investigation, this does not limit the findings of the present study, as we did demonstrate a clear change in DST%.

There was some heterogeneity: some participants showed very little change between conditions. Whether this heterogeneity indicates real subgroups or reflects random variation cannot be determined without appropriately powered studies. Subsequent research could explore potential subgroups, such as right *versus* left brain damage and impaired *versus* unimpaired balance/working memory span.

The absence of a control group means that the effects demonstrated cannot be causally attributed to the stroke. We simply aimed to determine whether these adverse effects occurred in stroke patients. Although not directly comparable, previous studies with young and older healthy controls did not find any adverse effects [2, 6]. One explanation is that these effects are only seen in people with compromised cognitive and motor systems (e.g. after a stroke). However, the differences between the patient and control studies may be due to methodological differences. In the control studies, the cognitive activity involved giving a verbal response to a non-verbal auditory signal (i.e. a tone). Since response to verbal auditory stimuli is a more realistic life-like activity, we used words rather than a tone. It is possible that the differences between the studies may be due to the different processing requirements of words and tones. Another explanation may be that the previous studies failed to detect effects—either because their measures were not made using a computerised gait analysis system such as our GaitMatII, [2] or they measured different variables. Dettinburn *et al.* [6] measured base of support and found no effects, whereas we measured DST% and did.

In our study, the verbal activity was simply a concurrent task unrelated to the walking activity. In contrast, the verbal interaction in real life is more likely to be relevant to the walking either as practical advice (e.g. positioning or sequencing instructions) or intended to motivate or reassure. Real-life interactions are also likely to be more complex, involving several higher level cognitive processes (such as sustained attention, language processing, remembering and sequencing). Unlike the

Table 2. Changes in mobility due to concurrent verbal activity

Factor	Mean value (SD) Walking only	Cognitive + walk	Mean difference (95% CI)	P-value (two-sided)
Velocity, m/s	0.64 (0.24)	0.57 (0.22)	−0.07 (−0.13, −0.02)	0.017
DST%	18.91 (4.60)	20.92 (5.89)	2.01 (0.59, 3.43)	0.010

CI, confidence interval; DST%, double-support time as a percentage of stride time.

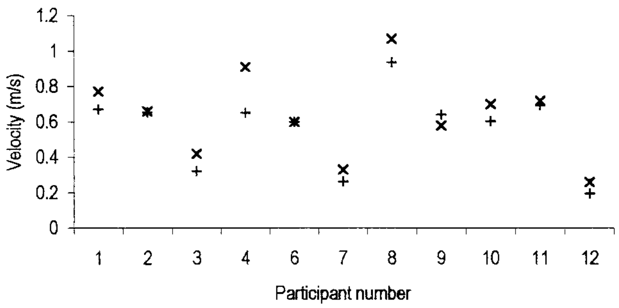

Figure 1. A comparison of participant's velocity under 'walk only' (×) and 'cognitive walk' (+) conditions.

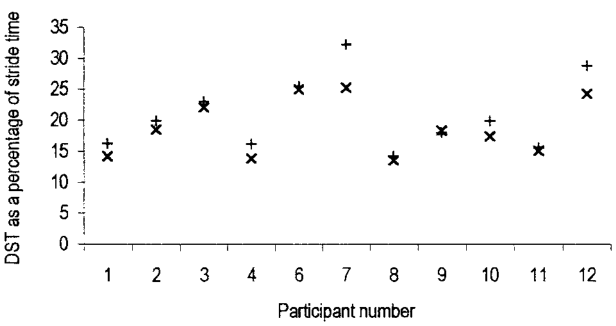

Figure 2. A comparison of each participant's double-support time (DST) as a percentage of stride time under 'walk only' (×) and 'cognitive walk' (+) conditions.

regularly occurring verbal activity in our study, real-life interactions may occur at less predictable times.

Before changing current clinical practice, the fundamental difference between the verbal interaction used in this study and that used in real-life therapy sessions must be acknowledged and investigated. Further studies could investigate this by including a naturalistic verbal setting (the participant receives verbal instruction on their mobility and is required to make an appropriate verbal response: for example, repeat the instruction or comment on their progress as they walk). Another interesting difference between our activity and real-life interaction is that our participants gave a verbal response—whereas in a therapy situation a physical response (i.e. a movement) may be more appropriate. The possible adverse effects of making a physical response could also usefully be investigated. These studies are necessary before we can make recommendations for clinical practice (such as that some stroke patients might benefit if talking was minimized during walking or conversely, that these patients might benefit from more practise at talking while walking in order to recover the ability to do both in real-life settings).

The present study cannot determine which of several aspects of the cognitive activity (sustain, divide or disengage attention) may have disrupted mobility. Ongoing research by Cockburn and colleagues is investigating the differential effects of four cognitive tasks in patients with acquired brain damage [14]. They found that both walking and cognitive activity were adversely affected but, like us, identified individual differences between patients. They plan to conduct subgroup analyses (such as site of lesion) of their sample.

In conclusion, we have shown that talking while walking slowed the walking speed and disrupted the balance of older stroke patients. This may have important implications for whether or not nurses and therapists use verbal instruction with all stroke patients during mobility rehabilitation sessions. Although an overall significant group effect was found, there was heterogeneity among the patients.

Further work is needed to investigate the possibility that certain clinical assessments may distinguish those most susceptible to interference from those who may benefit from verbal guidance. Most importantly, before changing current clinical practice, the effect of real-life meaningful verbal interaction on velocity and balance should be investigated.

Key points

- Walking while talking disrupted stroke patients' balance and gait velocity.
- Susceptibility to disruption varied within the patient group.
- Further research is required before changes to clinical practice are justified.

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