Neural Control of Curved Walking in People with Stroke

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Introduction

During curved walking, muscle activity and foot pressure distribution must be adapted according to path curvature in order to accommodate to the specific demands of turning.

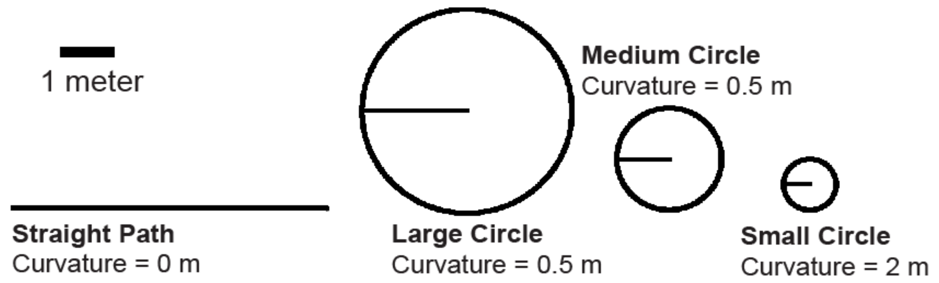
The purpose of this study was to assess whether stroke participants would adapt to the task of turning by modulating muscle activity and foot pressure distribution with changes to path curvature as seen in able-bodied individuals.

Methods

14 stroke participants and 9 able-bodied controls volunteered to participate.

Control	Age (years)	Time since stroke (years)	Affected side	Chedoke-McMaster Leg	Chedoke-McMaster Foot
1	68				
2	61				
3	72				
4	67				
5	70				
6	60				
7	57				
8	32				
9	35				
mean	*58*				
Stroke					
1	65	8	left	3	2
2	50	6	right	6	5
3	55	18	right	5	5
4	59	4	left	3	2
5	55	7	right	6	5
6	49	2	right	5	3
7	44	6.5	left	6	3
8	32	5	right	4	1
9	28	2	right	4	2
10	70	6	right		
11	50	9	right	3	1
12	68	4	right	6	6
13	54	5	right	2	3
14	63	16	right	6	4
mean	*53*	*7*			
median				*5*	*3*

Participants walked along four paths: straight line, large circle, medium circle and small circle at their self-selected speed.

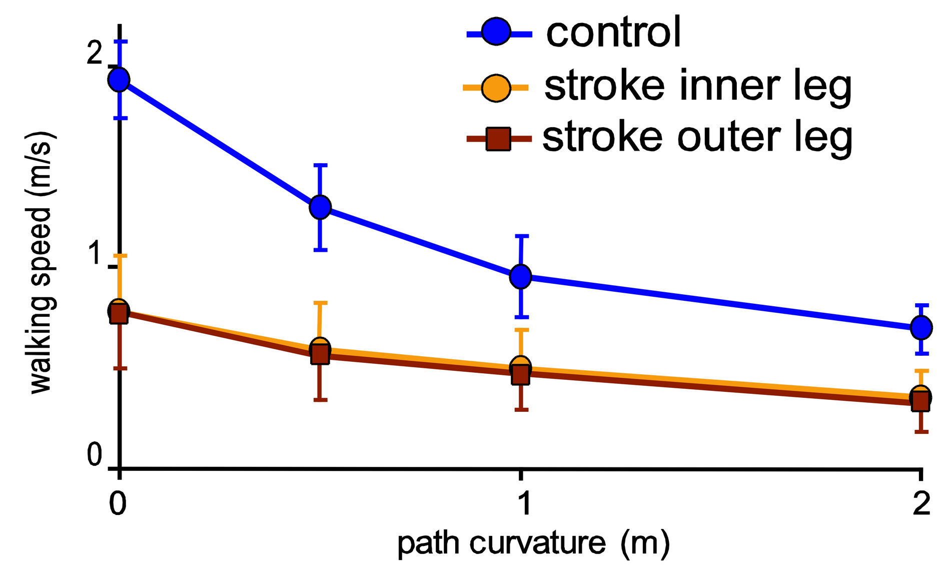


EMG was recorded from the following muscles: tibialis anterior (TA), medial (MG) and lateral gastrocnemius (LG), rectus femoris (RF), vastus lateralis (VL) and medialis (VM), medial hamstring (MH), biceps femoris (BF) and gluteus medius (GM) of the dominant leg (control participants) or paretic leg (stroke participants). Data were divided according to whether the leg was the inner or outer leg of the turn.

Force sensitive resistors (FSR) were placed under the heel, medial and lateral metatarsal heads to monitor foot pressure distribution.

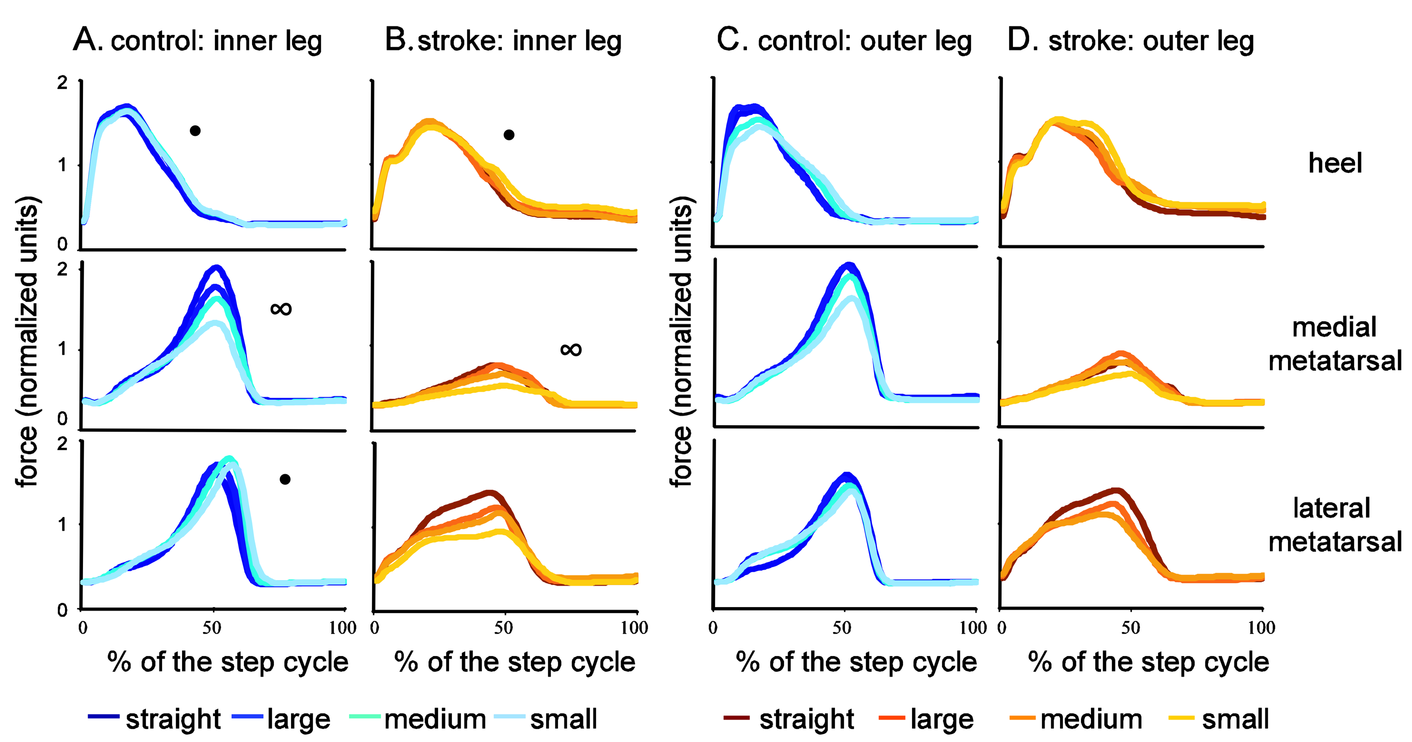
Results

1. Walking speed



Control participants walked faster than the stroke participants in every condition. Participants from both groups reduced their walking speed with increasing path curvature.

2. Foot pressure distribution



- *Denotes statistically significant differences in time to peak force between conditions ($p < 0.05$)*

∞ *Denotes statistically significant differences in peak force between conditions ($p < 0.05$)*

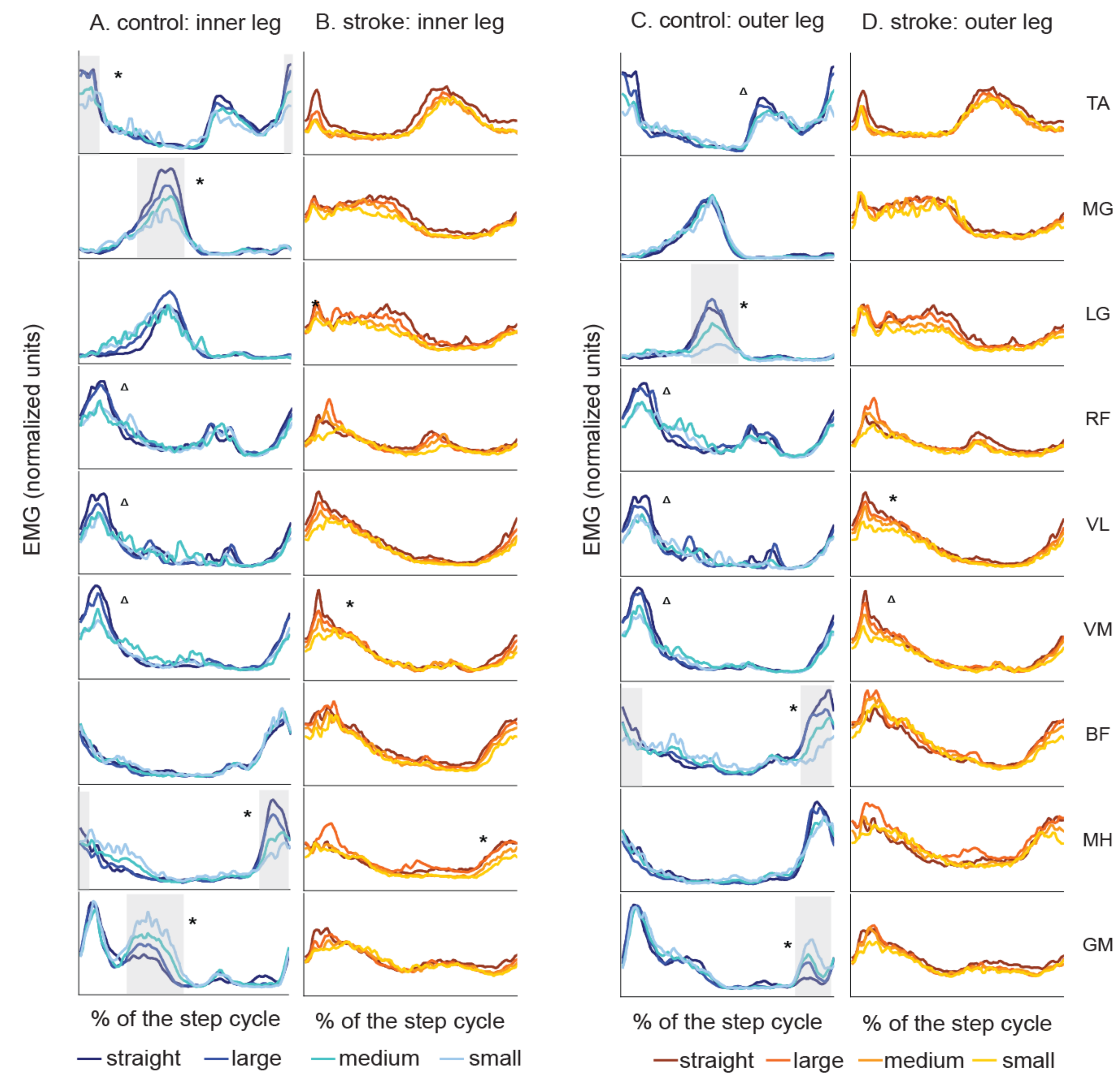
Control Participants:

■ Force distribution under the inner foot of the turn shifted from the medial to the lateral aspect of the foot with increasing path curvature.

Stroke Participants:

■ Although peak force under the medial metatarsal was significantly correlated to path curvature there was no corresponding shift towards the lateral aspect of the foot as observed in the control participants

3. Adaptation of muscle amplitude to path curvature



** Significant modulation due to changes in speed*

Δ Significant modulation due to changes in path curvature

Control Participants:

■ The modulation of muscle activity amplitude seen in the MG and MH of the inner leg and the LG and BF of the outer leg may serve to change body orientation and as a strategy to maintain balance while the body center of mass shifts towards the inside of the circular path.

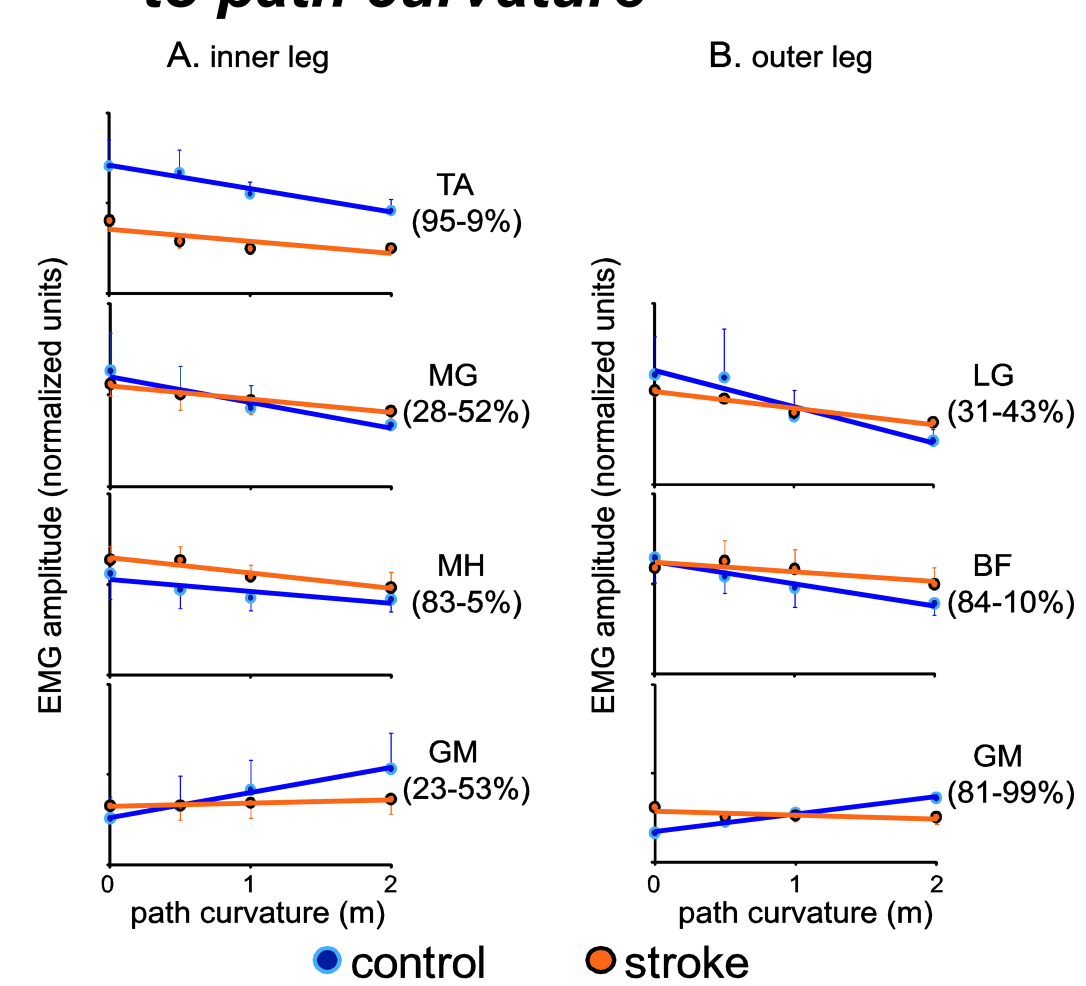
■ The increased amplitude of the GM of the inner leg during single stance as path curvature increased could serve to stabilize the upper body as the contra-lateral pelvis elevates.

■ The increased amplitude of the GM of the outer leg during swing phase would serve to increase leg adduction thus rotating the swinging leg in the direction of travel.

Stroke Participants:

■ These modulation patterns indicative of a shift of the center of mass towards the inside of the circle were not present in the stroke participants.

4. Modulation of the EMG amplitude of select muscles to path curvature



The average rectified EMG was calculated over a period of the step cycle during which path curvature had an effect on EMG amplitude. These periods are indicated with a gray box in the figure above.

Modulation of EMG amplitude was described with the slope of the line of best fit between the average rectified EMG amplitude and path curvature.

Summary

➢ Control participants modulated the amplitude of EMG of select leg muscle in order to allow the center of pressure to move towards the inside of the turn while maintaining balance.

➢Movement of the center of pressure and modulation of EMG amplitude were not seen in the paretic leg of the stroke participants in response to path curvature.

➢ The results of this study add to our understanding of how neural impairment due to stroke contributes to alter the ability to modulate motor output required for turning.