Curved walking in individuals with stroke

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Introduction

Despite the significance of turning during walking in everyday life there has been very little research on turning capacity in individuals with stroke-related hemiparesis.

During turning, temporal features required for straight walking become increasingly asymmetric when travelling along paths of increasing curvature. For example, the inner leg of the turn remains in single support longer compared to the outer leg. Joint angles of the lower leg are also adapted depending on path curvature.

During straight walking post-stroke, stance duration on the non-paretic side tends to be longer compared to the paretic side. The tendency to favour weight bearing on the non-paretic limb might restrict the extent to which inter-limb asymmetry can be adapted to increasing path curvature during turns to the paretic side (i.e.: when the paretic leg is the inner leg of the turn).

Aim

Do people with stroke adapt to the task of turning by modulating their pattern of temporal asymmetry and joint angle excursion according to the path curvature?

Methods

14 stroke and 9 able-bodied participants volunteered for this study.

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*

***Table 1** – Participant characteristics. Physical impairment due to stroke was assessed using the Chedoke-McMaster scale for the leg and foot.*

Participants were separated into a high-functioning group (score higher than 4 for both the leg and the foot) and a low-functioning group (score of less than 4 for both the leg and the foot)

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

Electrogoniometers were attached to the dominant leg of the control participants and the paretic leg of the stroke participants.

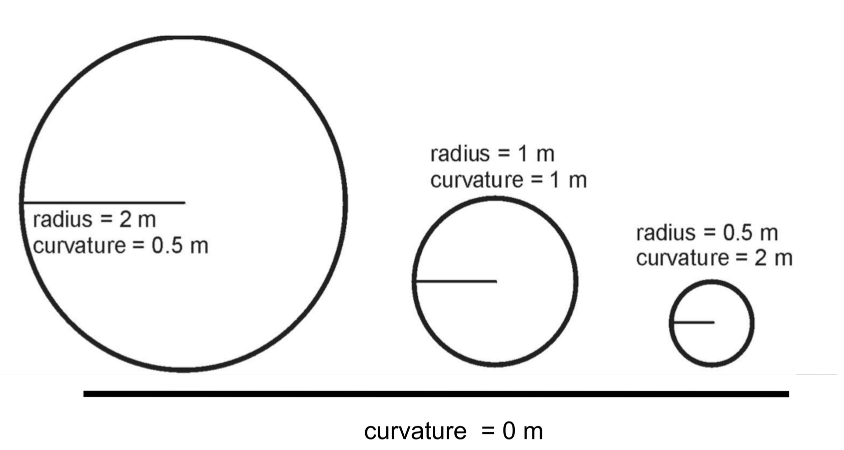

***Fig. 1**– Dimensions of the paths travelled.*

***Fig. 2**– Time spent on each leg was recorded with force sensitive resistors placed under the foot.*

The ratio of temporal asymmetry (RTA) indicates the time spent in single support on the inside leg relative to the outside leg.

A ratio of zero indicates temporal symmetry between both legs. A ratio greater than zero indicates more time spent in single support on the leg located on the inside of the turn relative to the outer leg.

$$RTA = \frac{\text{time spent on inner leg}}{\text{time spent on outer leg}} - 1$$

Results

1. Modulation of temporal asymmetry to path curvature

* Denotes a statistically significant difference between turns to the paretic/dominant side and turns to the non-paretic/non-dominant side

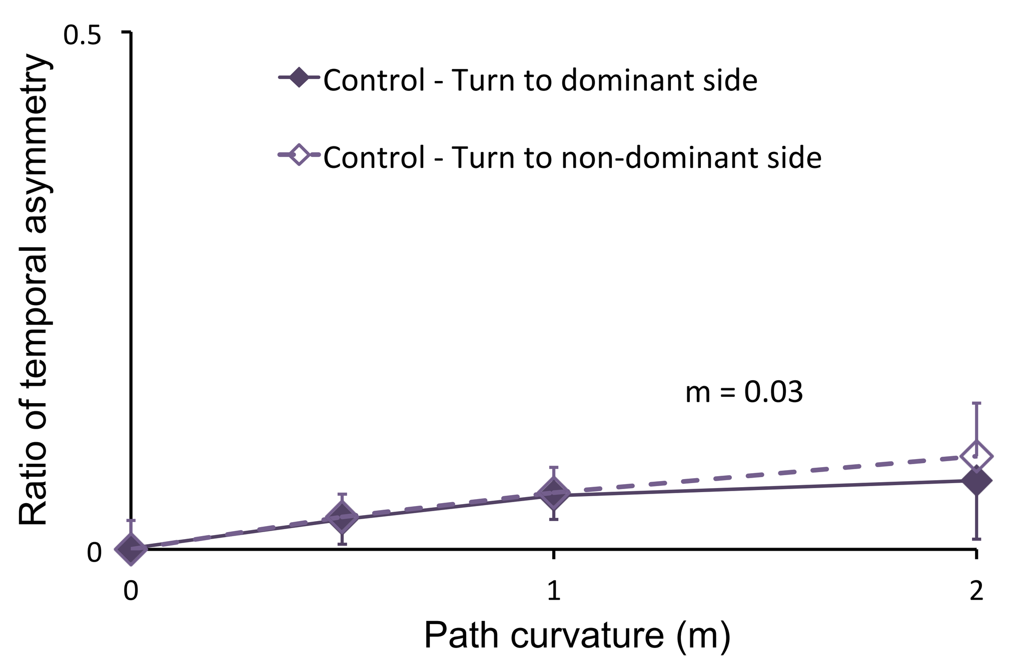

***Fig.3** – The control group spent more time on their inner leg with increasing path curvature.*

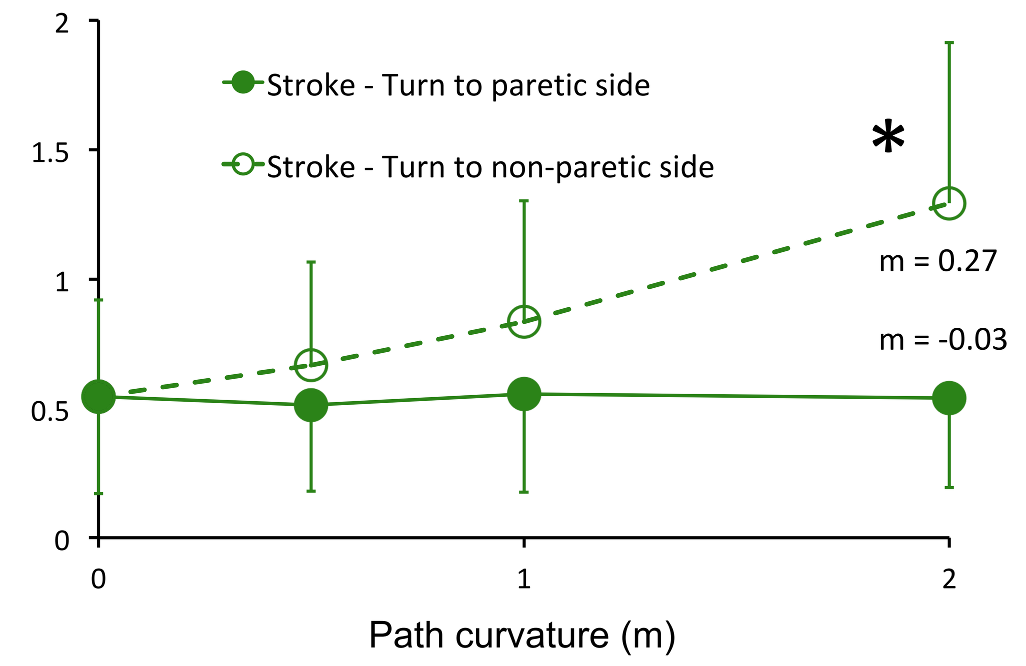

***Fig.4** –When turning to the paretic side stroke participants do not spend more time on the inside leg. When turning to their non-paretic side participants increased the time spent on their inner leg relative to the straight walking condition.*

2. Relationship to the degree of impairment

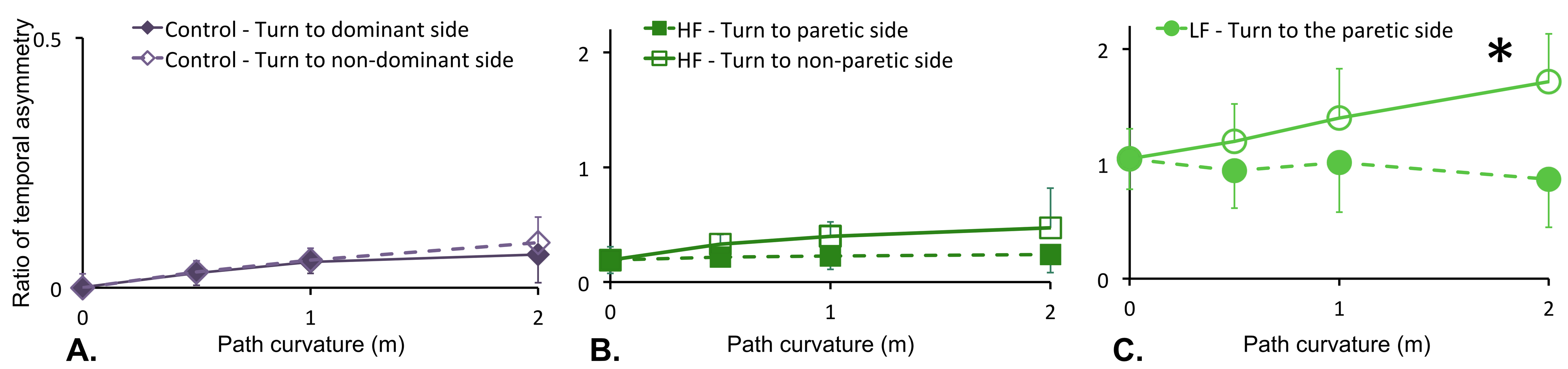

***Fig.5** – The participants were divided into three groups: **(A)** Control, **(B)** High-functioning stroke (HF) and **(C)** Low-functioning stroke (LF) based on their score on the Chedoke-McMaster assessment tool. **(B)** The HF group spent more time on the inner leg than the control group (mean difference = -0.14) during turns to the non-paretic side. **(C)** When turning to the paretic side, the LF did not spend more time on their inner leg with increasing path curvature relative to the control group. The LF group spent more time on their inner leg relative to their outer leg during turns to the non-paretic side compared to the HF group (mean difference = -0.20) and the control group (mean difference = -0.34) .*

3. Modulation of joint angle excursions to path curvature

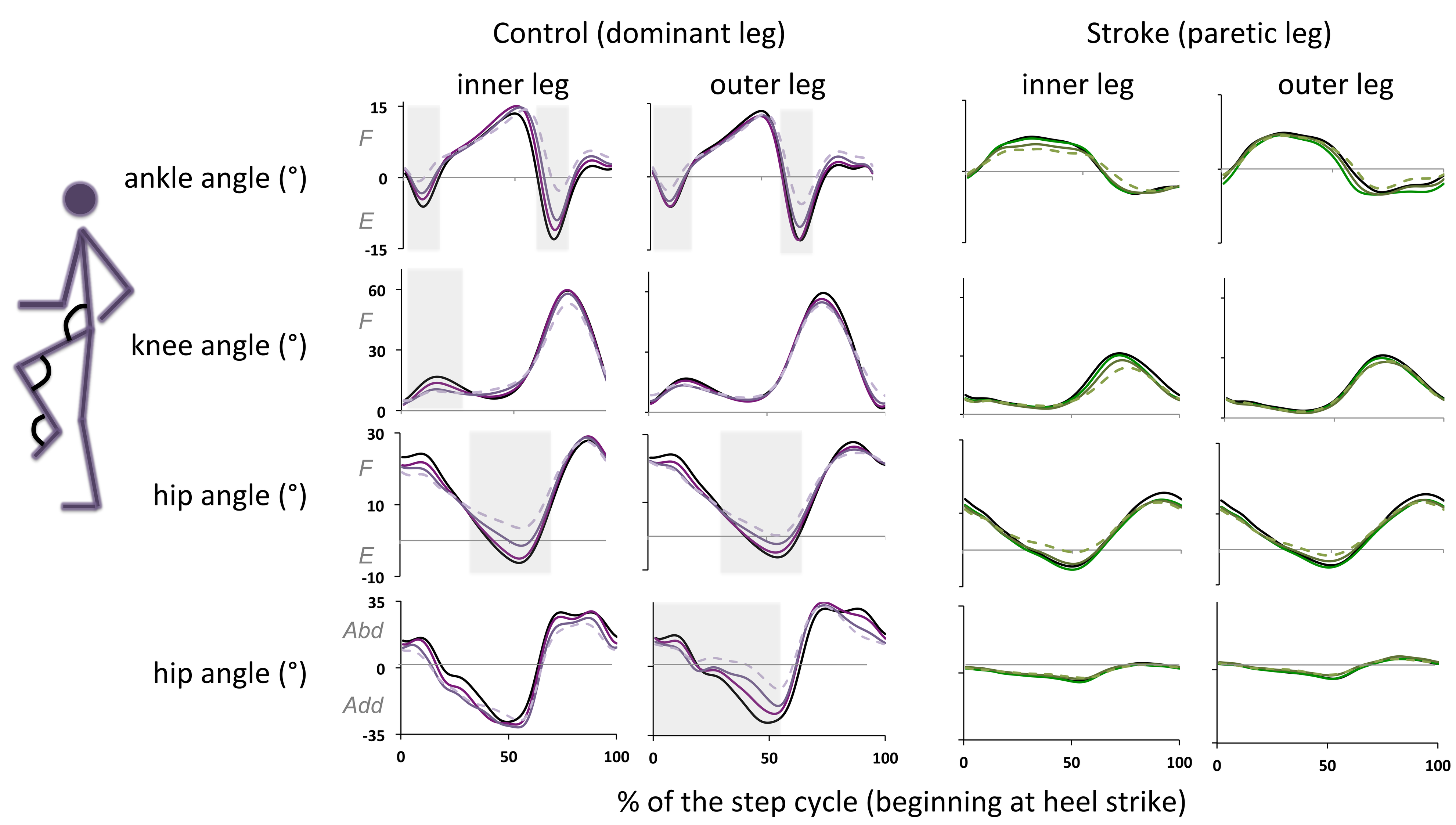

***Fig.6** – The control group modulated (statistically significant) peak ankle plantarflexion at push-off, peak ankle plantarflexion during loading, peak knee flexion at midstance (inner leg), peak hip extension during pre-swing and the range of hip abduction during stance phase (outer leg) according to path curvature (shaded areas). The stroke group did not adapt the joint excursion of the paretic leg in response to path curvature.*

Conclusion

Turns to the paretic side did not change the degree of asymmetry relative to the straight walking trials but participants did increase the time spent on the non-paretic limb when turning to the non-paretic side.

There is a negative relationship between the degree of physical impairment and the ability to adopt an asymmetric walking pattern in response to path curvature.

Stroke participants do not modulate lower limb kinematic patterns of their paretic limb according to path curvature.

Acknowledgements

We thank Kathryn Luttman and Catherine Chan for their valuable assistance in the collection of the data.

KD is supported by a scholarship from the Natural Sciences and Engineering Research Council of Canada.

This study is being supported by the Canadian Institutes of Health Research.