Immediate Effects of Cane Use on Gait Symmetry in Individuals with Subacute Stroke

Marla K. Beauchamp, Martina Skrela, Degen Southmayd, Jaime Trick, Meghan Van Kessel, Karen Brunton, Elizabeth Inness, William E. McIlroy

ABSTRACT

Purpose: In stroke rehabilitation, there is a lack of consensus regarding the effects of cane use on gait symmetry. This study aimed to evaluate the immediate effects on gait symmetry of ambulating with a standard cane and a quad cane among individuals with subacute stroke.
Method: A within-subject experimental design was used to evaluate symmetry in in-patients with subacute stroke during ambulation on a pressure-sensitive walkway for three task conditions: with no cane, with standard single-point cane, and with quad cane.
Results: Fourteen patients were classified as symmetric ($n = 5$) or asymmetric ($n = 9$) based on their gait symmetry while walking without an aid. Overall, use of a standard cane during ambulation significantly improved symmetry in asymmetric patients ($p = 0.028$). In contrast, the use of a quad cane did not improve symmetry ($p = 0.36$). There was no effect on symmetry in symmetric patients with use of either a standard cane ($p = 0.88$) or a quad cane ($p = 0.32$).
Conclusions: These results indicate that the immediate effect of a standard cane is to improve symmetry in patients with subacute stroke who have asymmetric gait. Future studies are required to determine the long-term effects of canes on gait symmetry in this population.

Key Words: gait aid, hemiparetic gait, quad cane, rehabilitation, spatiotemporal parameters, standard cane, stroke, symmetry

Beauchamp MK, Skrela M, Southmayd D, Trick J, Van Kessel M, Brunton K, Inness E, McIlroy WE. Immediate effects of cane use on gait symmetry in individuals with subacute stroke. Physiother Can. 2009; 61:154-160.

RÉSUMÉ

Objectif : En réadaptation à la suite d'un accident vasculaire cérébral (AVC), les effets de l'utilisation d'une canne ordinaire sur la symétrie de la démarche ne font pas consensus. Cette étude a pour objectif d'évaluer les effets immédiats de la démarche avec une canne ordinaire et avec une canne quadripode sur la symétrie de la démarche, dans la phase subaigu, chez les personnes ayant subi un AVC.
Méthodes : Un modèle expérimental de comparaison chez le même patient a été utilisé pour évaluer la symétrie dans la phase subaigu chez des patients hospitalisés à la suite d'un AVC dans le cadre de l'exécution de trois tâches : ambulation sur une passerelle sensible à la pression sans canne, avec une canne à un seul point de contact et avec une canne quadripode.
Résultats : Quatorze patients ont été identifiés comme symétriques ($n = 5$) ou asymétriques ($n = 9$) en fonction de la symétrie de leur démarche sans aide. Dans l'ensemble, l'utilisation d'une canne ordinaire lors de l'ambulation améliore considérablement la symétrie des patients asymétriques ($p = 0{,}028$). Au contraire, l'utilisation d'une canne quadripode n'a pas amélioré la symétrie ($p = 0{,}36$). Aucun effet sur la symétrie des patients symétriques n'a été constaté avec l'utilisation d'une canne ordinaire ($p = 0{,}88$) ou d'une canne quadripode ($p = 0{,}32$).
Conclusions : Ces résultats indiquent que l'effet immédiat d'une canne ordinaire est d'améliorer la symétrie chez les patients dans la phase subaigu suivant un AVC ayant une démarche asymétrique. Des études futures seront nécessaires pour établir les effets à long terme des cannes sur la symétrie de la démarche de cette population.

Mots clés : AVC, accident vasculaire cérébral, aide à la marche, canne ordinaire, canne quadripode, démarche avec hémiparésie, paramètres spatiotemporels, réadaptation, symétrie

No competing interests and source of funding are declared for this paper.

Marla Beauchamp, Martina Skrela, Degen Southmayd, Jaime Trick, and Meghan Van Kessel completed this research in partial fulfilment of the requirements for an MScPT degree at the University of Toronto.

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DOI:10.3138/physio.61.3.154

INTRODUCTION

Improved walking function is the goal most often stated by individuals living with stroke, and restoration of efficient and independent gait is a primary therapeutic goal.[1,2] In contrast with normal gait, individuals post-stroke demonstrate a preference for weight-bearing on the non-paretic limb, resulting in gait asymmetry.[3] Spatiotemporal characteristics of hemiparetic gait include a decrease in (1) propulsion on the paretic side, (2) duration of stance phase on the paretic side, (3) step length on the non-paretic side, and (4) walking speed.[4] Several of these produce asymmetry in gait, and if such asymmetries persist, individuals may experience pain, joint damage, increased energy expenditure, and increased incidence of falls.[5–7] Therefore, promoting a symmetrical gait pattern is important for maximizing independent mobility among patients with stroke.

Gait aids such as walkers and canes have long been used to help individuals with stroke achieve independent gait. It has been reported that as many as 76% of patients use at least one gait aid 3 months post-stroke.[8,9] Despite this, evidence-based guidelines for the prescription of canes in stroke rehabilitation remain scarce.[10] In addition, there is a persistent belief that gait aids may encourage weight shift away from the paretic limb, increasing the severity of asymmetry.[11] In light of this specific concern, there is a need for studies to determine the influence of cane use on gait symmetry in individuals post-stroke.

To date, studies have failed to show any significant effects of cane use on gait symmetry or velocity.[12–14] However, research has focused mainly on patients with chronic stroke and has not always considered the gait characteristics of these patients.[12–14] Specifically, the impact of an aid on gait symmetry in individuals with pre-existing gait asymmetry has not been examined. Furthermore, the effect of a gait aid may be difficult to assess if patients have become accustomed to its use. Research is thus warranted to provide further insight into the immediate effects of both cane use and baseline gait asymmetry in patients with subacute stroke in the early phases of rehabilitation.

The primary objective of this study was to evaluate the immediate effect of cane use on gait symmetry in asymmetric patients with subacute stroke unaccustomed to use of a cane for ambulation. We hypothesized that use of a cane would improve symmetry only in those patients with pre-existing gait asymmetry. Secondary objectives were (1) to evaluate the immediate effects of cane use on gait symmetry in symmetric patients and (2) to evaluate the immediate effects of cane use on velocity in symmetric and asymmetric patients.

METHODS

Subjects

Patients with stroke were recruited from an in-patient stroke rehabilitation unit at the Toronto Rehabilitation Institute between March and July 2007. Inclusion criteria were as follows: (1) first clinical diagnosis of stroke; (2) less than 3 months post-stroke; (3) ability to understand and follow oral commands; (4) ability to give informed consent; (5) ambulatory without a gait aid before current stroke; (6) ambulatory without a gait aid for 6 m with close, non-contact supervision; and (7) ''naïve'' to use of an aid (i.e., patient had not integrated a cane into daily living). Patients with the following conditions were excluded: (1) severe arthritis or previous lower-extremity orthopaedic surgeries; (2) lower-limb amputation(s); and (3) other neurological conditions influencing gait. Ethics approval for this study was received from the Toronto Rehabilitation Institute and the University of Toronto. Written informed consent was obtained from all patients prior to their participation in the study.

Instrumentation

Spatiotemporal measures of gait were recorded using a $4.60\,m \times 0.90\,m$ pressure-sensitive walkway, the GAITRite system (CIR Systems Inc., Clifton, NJ). Studies have found that the GAITRite mat has strong concurrent validity and test–retest reliability for the measurement of spatial and temporal gait parameters in healthy individuals and in populations with gait abnormalities.[15–18] The system also has the ability to detect changes in symmetry in patients post-stroke.[19]

Study Protocol

Patients were instructed to walk a distance of 6 m wearing their regular footwear. Ankle–foot orthoses or similar external ankle supports were permitted if used regularly during ambulation. The pressure-sensitive mat was placed in the middle of a walkway and an additional 2 m was provided on either end of the mat to minimize the effect of acceleration and deceleration on data collection. A within-subject study design was used; each patient completed three passes of three walking tasks at his or her preferred walking pace. Task conditions were as follows: (1) no cane task; (2) standard single-point cane task; (3) quad cane task.

Using a table of random numbers, the task sequence was randomized between patients to minimize associated training and order effects. Patients were closely supervised by a registered physical therapist during all tasks and were allowed to rest between tasks as needed. If external support was required, or if footsteps did not fall within the active area of the mat, data were excluded and the pass repeated. Stages of motor recovery for the leg and foot were obtained from the medical chart for each patient, assessed within an average of 1 week from testing. Motor recovery was assessed by the treating therapists using the Chedoke-McMaster Stroke Assessment (CMSA), which quantifies impairment levels on a seven-point staging system based on Brunnstrom's[20] six stages of motor recovery; lower scores indicate greater motor impairment.[21] The reliability and validity of the CMSA as a measure of motor impairment in patients post-stroke has been reported previously.[21]

Data Analysis

Raw spatiotemporal data collected from the GAITRite system were processed using GAITRite software. Occurrences of cane marks and/or footmarks of spotting therapists were removed prior to analysis of footfalls. Spatiotemporal data for the three passes of each walk task were averaged for analysis. For the purpose of this study, the following definitions were used:

1. *Swing time:* elapsed time between toe off and heel strike of the ipsilateral foot;
2. *Stance time:* elapsed time between heel strike and toe off of the ipsilateral foot;
3. *Baseline symmetry:* average gait-symmetry value calculated while walking without an aid.

A gait-symmetry value was calculated to quantify temporal symmetry for each task condition. Symmetry was defined as follows:

$$\text{Symmetry} = \frac{\text{paretic swing time} \,/\, \text{paretic stance time}}{\text{non-paretic swing time} \,/\, \text{non-paretic stance time}}$$

Such an index of symmetry has been shown to represent a meaningful classification of ambulators post-stroke and has been found to be well correlated with walking velocity and motor impairment of the foot and leg in patients with stroke.[22–24] A value of 1.0 ± 0.1 (mean $\pm$ SD) indicates symmetry, reflecting equal time spent in stance for both limbs. Values greater than 1.0 indicate a relative increase in non-paretic stance time.[25]

For the purposes of statistical analysis, patients were classified into two groups—*symmetric* (symmetry $= 1 \pm 0.1$) and *asymmetric* (symmetry > 1.1)—based on their baseline gait-symmetry value. Descriptive statistics, including mean and standard deviation (mean $\pm$ SD), were computed to summarize participant characteristics and within-subject results. The assumption of normality was assessed by graphical (frequency histograms and box plots) and statistical methods (Shapiro-Wilks test). Paired Student's *t*-tests were used in both groups to determine the statistical significance of differences in symmetry and velocity between tasks. In accordance with our primary hypothesis, a 1-tailed test of significance was performed for change in symmetry in asymmetric patients; all other tests were 2-tailed. In all cases, statistical significance was denoted by an alpha level of ≤ 0.05.

RESULTS

A total of 14 patients met the inclusion/exclusion criteria and were tested in this study; five patients were classified as symmetric (baseline symmetry $= 1.0 \pm 0.1$) and nine patients as asymmetric (baseline symmetry > 1.1). Demographics of the study population are provided in Table 1 (mean age 61 ± 10 years, time post-stroke 50 ± 26 days). All 14 patients were male.

Effect of Cane Use on Gait Symmetry

Symmetry values and mean differences for each task condition are outlined in Table 2 for all study participants. Among asymmetric patients ($n = 9$), a statistically significant improvement from baseline was found for gait

Table 1 Participant Demographics, Stage of Motor Recovery at Time of Testing, and Baseline Symmetry Values

Patient	*Age (yrs)*	*Height (cm)*	*Mass (kg)*	*Type of Stroke*	*Location of Stroke*	*Paretic Side*	*# Days Post-stroke*	*CMSA Leg*	*CMSA Foot*	*AFO*	*Baseline Symmetry*	
1	62	171	77	H	Lentiform nucleus	L	20	4	4	Y	0.986	*Symmetric*
2	77	163	67	H	Thalamus	L	81	6	6	N	1.003	
3	43	178	87	I	MCA territory	L	85	7	6	N	1.014	
4	48	172	119	I	Middle pontine	L	27	5	4	N	1.059	
5	74	169	84	H/I	Basal ganglia	L	12	5	3	N	1.095	
6	71	173	108	I	Parietal	L	49	6	6	N	1.122	*Asymmetric*
7	57	176	91	I	Pons	L	33	4	5	N	1.133	
8	54	173	86	I	MCA territory	L	64	4	4	N	1.155	
9	56	171	57	I	Parietal/internal capsule	L	40	5	4	N	1.251	
10	63	171	80	I	Lacunar	R	27	5	3	N	1.311	
11	74	181	71	H	Temporal-occipital	R	36	4	4	N	1.312	
12	54	154	87	I	Lacunar	R	52	5	3	N	1.329	
13	58	171	67	I	Parietal	R	85	4	2	Y	1.769	
14	61	163	72	I	Thalamus	L	90	4	2	Y	2.177	
Mean ± SD	61 ± 10	170 ± 7	82 ± 16				50 ± 26				1.265 ± 0.331	

H = haemorrhage; I = infarct; R = right; L = left; CMSA = stage of motor recovery assessed using the Chedoke-McMaster Stroke Assessment; AFO = ankle–foot orthosis.

Table 2 Change in Symmetry with Standard Cane and Quad Cane Compared to Baseline for All Patients

Patient	*Baseline Symmetry*	*SC Symmetry*	*QC Symmetry*	*Change in Symmetry with SC*	*Change in Symmetry with QC*	
1	0.986	0.997	1.005	−0.011	−0.019	Symmetric
2	1.003	1.050	1.139	−0.048	−0.137	
3	1.014	1.065	1.137	−0.052	−0.123	
4	1.059	1.024	1.028	0.035	0.031	
5	1.095	0.998	1.058	0.098	0.038	
Mean ± SD	1.031 ± 0.045	1.027 ± 0.031	1.073 ± 0.062	0.004 ± 0.063	−0.042 ± 0.083	
6	1.122	1.107	1.110	0.015	0.012	Asymmetric
7	1.133	1.207	1.032	−0.074	0.101	
8	1.155	1.188	1.252	−0.033	−0.097	
9	1.251	1.173	1.472	0.078	−0.221	
10	1.311	1.137	1.545	0.174	−0.234	
11	1.312	1.279	1.148	0.033	0.164	
12	1.329	1.199	1.299	0.130	0.031	
13	1.769	1.653	1.591	0.116	0.178	
14	2.177	1.932	1.906	0.245	0.271	
Mean ± SD	1.395 ± 0.352	1.319 ± 0.281	1.373 ± 0.280	0.076 ± 0.102	0.023 ± 0.177	

SC = standard cane; QC = quad cane.

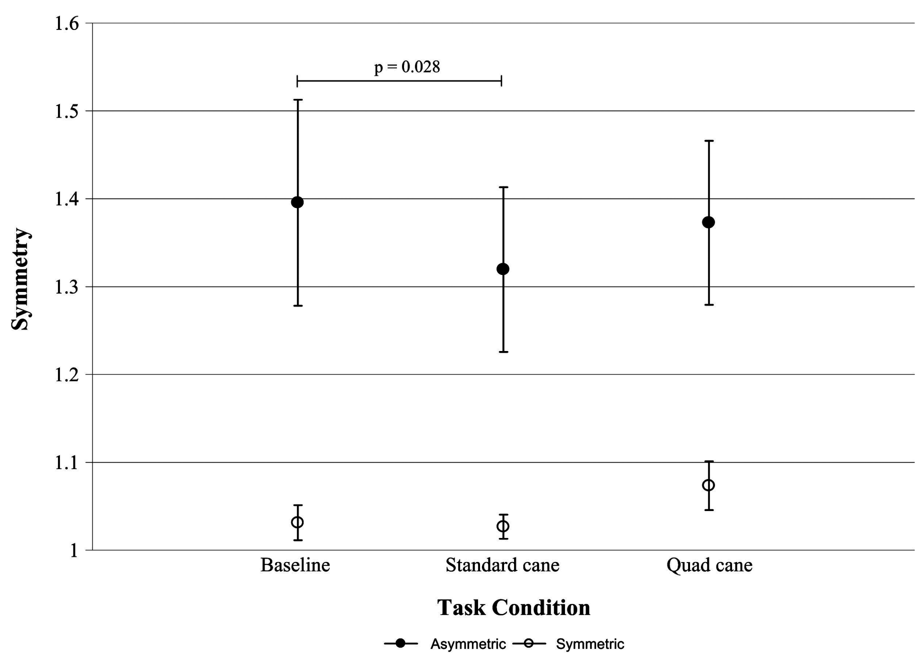

Figure 1 Comparison of mean symmetry and standard error for each task condition in symmetric ($n = 5$) and asymmetric ($n = 9$) patients

symmetry with the standard cane ($t_8 = 2.24$, $p = 0.028$) (see Figure 1). Note that four of the most severely asymmetric patients showed the greatest improvement in symmetry (> 0.1) walking with the standard cane compared to patients who were mildly asymmetric (see Table 2). There was no statistically significant difference in gait symmetry with the quad cane compared to baseline ($t_8 = 0.39$, $p = 0.36$; see Figure 1).

In symmetric patients ($n = 5$), there were no statistically significant differences in gait symmetry with the use of either a standard cane ($t_4 = 0.16$, $p = 0.88$) or a quad cane ($t_4 = -1.13$, $p = 0.32$) compared to baseline (see Figure 1).

Effect of Cane Use on Velocity

In the asymmetric group, there was no change in mean velocity with the standard cane compared to baseline (mean difference $= -0.04 \pm 0.07$, $t_8 = 1.49$, $p = 0.18$). However, mean velocity significantly decreased during the quad cane task (mean difference $= -0.13 \pm 0.15$, $t_8 = 2.54$, $p = 0.035$). Patients classified as symmetric demonstrated no change in velocity during either the standard cane task (mean difference $= -0.09 \pm 0.09$, $t_4 = 2.29$, $p = 0.08$) or the quad cane task (mean difference $= -0.09 \pm 0.11$, $t_4 = 1.68$, $p = 0.17$) compared to baseline.

DISCUSSION

The findings of this study show that the immediate effect of ambulating with a standard cane is to improve gait symmetry in patients with subacute stroke and asymmetric gait. In addition, the use of a quad cane had minimal effects on symmetry and decreased walking velocity in these patients.

While the improvement in gait symmetry with a standard cane was found to be statistically significant, a clinically meaningful difference in gait symmetry has yet to be established in the literature. However, a symmetry value of 1.0 ± 0.1 has been reported as an appropriate range for identifying patients with normal symmetry.[25] We suggest, therefore, that a change of 0.1 may have clinical relevance. Based on our results, we cannot rule out a clinically significant improvement for asymmetric patients (mean improvement in symmetry $= 0.08 \pm 0.10$, $n = 9$) ambulating with a standard cane. As Table 2 shows, four of the patients with more severe asymmetry demonstrated a change in symmetry greater than 0.1 for this task condition.

Few studies have investigated the effect of cane use on temporal measures of gait symmetry.[9–14] To date, our study is the first to demonstrate a significant improvement in symmetry with the use of a gait aid. One reason for this discordance may be that patients who demonstrated baseline gait asymmetry were analyzed separately from those with normal baseline gait symmetry. Previous work has suggested that severity of hemiplegia is an important determinant of patients' response to gait aids.[13] Further, given that patients with lower levels of motor recovery tend to exhibit more asymmetric gait,[24–26] we had anticipated that canes would have a positive effect in patients with baseline gait asymmetry. Thus, analyzing symmetric and asymmetric patients together would likely have attenuated measured differences in symmetry associated with cane use. Moreover, in contrast to participants in previous investigations, patients in this study were less than 3 months post-stroke and had not been independently ambulating with a cane prior to participating in the study. This may suggest that time post-stroke and acclimatization to an aid affect the degree of benefit derived from gait training with a cane.

Several factors may account for the observed improvement in symmetry when walking with a standard cane, including increased confidence, stability, and weight-bearing through the cane.[9,27–29] It has also been shown that use of a standard cane results in less muscular effort and normalization of muscle activation and muscle timing in patients with stroke.[30] This finding is in agreement with new evidence suggesting that partial body weight support treadmill training is an effective method to improve hemiparetic gait quality. Specifically, unloading the lower extremities appears to be an important factor in retraining balance and facilitating use of the paretic limb, resulting in improved motor control.[31,32] Thus it is possible that, in the current study, the use of a standard cane may have assisted in unloading the paretic limb in stance phase, providing an opportunity to improve symmetry.

Similar to previous studies,[12,29] our work demonstrated no immediate changes in symmetry with use of a quad cane for ambulation in either asymmetric or symmetric patients. A possible explanation for this lack of change is that the wider base of support may require a longer period of familiarization than the standard cane. In support of this explanation, our results showed a trend toward increased symmetry with use of a quad cane in asymmetric patients; however, post-hoc power calculations indicated that we were considerably underpowered to detect a significant change for this task condition (power $= 0.08$).

It has been suggested that severity of hemiparesis is an important determinant of a patient's response to gait aids.[13] In the current study, patients who were more severely asymmetric demonstrated greater improvements in symmetry than those who were mildly asymmetric. In fact, the most severely asymmetric patient achieved the greatest improvement in gait symmetry with use of a standard cane. Given the association between severity of hemiparesis and asymmetry,[24,25] these results may suggest that the positive effect of standard cane use on gait symmetry is more pronounced in patients with greater motor deficits. However, further investigation is required to confirm this relationship because of the small sample of asymmetric patients in this study.

Slower gait speeds in patients with stroke compared to age-matched controls have consistently been reported in the literature.[33–36] Previous studies have failed to find a significant difference in velocity between walking with and walking without a standard cane.[9,37] Similarly, results from the current study do not reveal a significant change in mean velocity when asymmetric patients walked with and without a standard cane. Therefore, the improvement in symmetry reported here cannot simply be attributed to changes in velocity.

Limitations

The major limitation of this study is the small sample size, which reduces the generalizability of our results. The applicability of our findings to a general stroke population is also limited by the sample of convenience, in which all participants were male. However, admission data from the recruitment site during the 3 months of testing indicate that only 34% of stroke in-patients were female. Furthermore, women may have been less likely to meet our inclusion criteria, given their higher level of impairment post-stroke.[38,39] Finally, while this study reports the immediate effect of use of a cane for ambulation, long-term effects remain unknown.

CONCLUSIONS

Results from the present study show that the immediate effect of introducing a standard cane for ambulation in patients with subacute stroke is to improve temporal gait symmetry in asymmetric patients. By contrast, use of a cane for ambulation by symmetric patients did not affect gait symmetry. This study thus does not provide support for the concern that use of a cane promotes an asymmetric walking pattern in patients in the initial phases of post-stroke rehabilitation. The results for quad canes are less clear and warrant further examination.

Findings from this study highlight the need for additional investigations into the role of canes in achieving early stroke rehabilitation goals, specifically the improvement of gait symmetry. Future research is also necessary to determine the long-term effects of gait aids on gait symmetry and overall walking competence.

KEY MESSAGES

What Is Already Known on This Subject

Previous studies investigating the effect of cane use on gait symmetry and velocity have not demonstrated any significant effects. However, these studies have been conducted mainly with patients with chronic stroke who have had formal training with the device. In addition, baseline gait characteristics such as symmetry have not been considered.

What This Study Adds

This study aimed to investigate the immediate effects of cane use on gait symmetry in patients with asymmetric gait and subacute stroke. Our results provide the first evidence that use of a standard cane for ambulation improves symmetry in patients with asymmetric gait.

ACKNOWLEDGEMENTS

The authors sincerely thank Dr. Dina Brooks for her valuable editorial comments during the preparation of this manuscript. The authors would also like to acknowledge the patients and physical therapists on the stroke unit at the Toronto Rehabilitation Institute.

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