

The Effect of a Knee Brace on Gait Parameters of Hypertonic Hemiplegic Patients

ABSTRACT: *The aim of this study was to investigate the effects of the use of a knee brace on 15 subjects with hypertonic hemiparesis. The middle cerebral artery was involved in all subjects. The Ashworth scale was used to screen for the presence of spasticity in the quadriceps muscles.*

Measurements of gait speed, step and stride length were taken in the middle 10 metres of a 15 metre paper walkway. A comparison of these gait parameters without and with the use of a knee brace was made. A questionnaire was also used to evaluate how subjects responded to the use of a knee brace.

The results showed that the mean speed for all 15 subjects increased with the use of a brace, ($p = 0.05$). Step and stride length without and with the use of a brace showed no statistical differences.

It was therefore concluded that the FECK brace appears to have an effect on the walking speed of subjects with hypertonic hemiparesis

KEY WORDS: KNEE BRACE, GAIT PARAMETERS, HYPERTONIC, HEMIPLEGIA.

INTRODUCTION

The limited walking ability which follows a stroke restricts patients' independent mobility about the home and community (Perry et al, 1995). A highly desired goal amongst stroke victims is independent walking (Hale and Eales, 1998). However patients want to walk normally and want to be cosmetically acceptable (Turnbull and Wall, 1989). One of the most common deviations of gait following a stroke is hyperextension of the knee (Mosely et al, 1993). This is defined as extension of the knee beyond the neutral position. This is a common complication of spasticity in hemiplegia due to over-activity of the quadriceps (Whittle, 1991). Whittle (1991) also points out that the hyperextension moment is initially resisted by tension in the posterior joint capsule, which is gradually stretched allowing a hyperextension deformity '*Genu Recurvatum*'

to develop. Despite the findings that 40% to 68% of stroke patients suffer from knee hyperextension little attempt has been made to compare the effectiveness of different management approaches to this problem (Morris et al, 1992). Using the knee brace

Knee hyperextension is an impairment that is likely to cause undesirable effects. According to Whittle (1991) knee hyperextension deformity frequently leads to the development of osteoarthritis in later life. In the Hale and Eales (1998) study, one third of the sample of 54 stroke subjects experienced knee pain during walking, which was considered as a complication of knee hyperextension.

Many government hospitals in South Africa have too few rehabilitation therapists to cope with the large numbers of stroke patients. The patients who are admitted only receive minimal rehabilitation and are not in hospital long enough for any meaningful functional improvement to occur (Hale and Eales, 1998). Treatment for many stroke patients is likely to be discontinued before full functional recovery is reached (Turnbull and Wall, 1989).

Due to limited rehabilitation facilities, the problem of knee hyperextension

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is inadequately addressed and gait is often trained irrespective of knee hyperextension not been resolved in stroke patients. Realistically, gait rehabilitation of a patient with knee hyperextension becomes less effective, as the hyperextension contributes to the asymmetry of the gait pattern.

The flexion/extension control knee brace, the 'FECK brace', may be suitable to provide stability of the knee in the absence of sufficient quadriceps control. This potentially could be useful to facilitate weight bearing while gaining muscle control. This knee brace, commonly available in most government hospitals is currently used for immobilising the knee after anterior cruciate ligament repair.

The objective of this study was to establish whether the knee brace, supporting the hemiparetic leg, increases the speed of walking, the stride length and step length. These measurements have also been shown to correlate with improved functional gait (Riley et al, 1996).

METHODOLOGY

Prior to the commencement of this study ethical clearance was obtained from the Committee for Research on

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Human Subjects at the University of the Witwatersrand. This study was conducted at various community clinics in Soweto (ie Zola, Mfolo and Chiawelo).

Sample Selection

Every patient who had had a stroke who attended the clinic for exercise class on the day data were collected, was screened to identify if he/she met the inclusion criteria of the study. A sample size of 15 subjects was selected.

Inclusion Criteria

- Patients who had had a stroke in the middle cerebral artery territory as identified in patients' records.
- Males and females
- Adults (above the age of 20)
- Left or right hemiparesis
- Observable knee hyperextension on the paretic side during the stance phase of gait.
- Ability to walk at least 15 metres.

Exclusion Criteria

- Bilateral hemiplegia / hemiparesis
- Hip flexion contractures
- Ankle (Tendon Achilles) contracture
- Acute inflammation in the knee indicated by increased temperature and swelling.

STUDY DESIGN

A cross sectional study design was used.

Informed consent

A written informed consent form was obtained from 15 hemiplegic subjects as they agreed to participate in the study.

Medical Records

Study included subject with right middle cerebral artery involvement – confirmed with medical records.

Inclusion Criteria

The presence of hyperextension in the paretic knee during the weight bearing phase of walking. (This was observed independently by the first author and a second physiotherapist).

2/4 muscle tone in the quadriceps and gastrocnemius (Ashworth Scale, 1964). (The test was done with the subject lying in a supine position. Muscle tone qualifies as 2/4 when the marked increase in tone is palpated through full range of

movement and yet the limb moves easily).

Exclusion Criteria

Hip and ankle contractures (assessed using Thomas' test for the hip and passive range of movement for the ankle. Thomas test - subject in supine lying, unaffected leg is held against the subject's chest to straighten the lumbar spine. The leg lying on the plinth is observed, if the knee flexes and does not straighten when the thigh is pressed down to the plinth, the test is considered positive for the presence of a hip contracture on the limb tested).

Acute inflammation of the knee (assessed by observation and palpation).

Subjects

15 subject participated in the study (10 males and 5 females). Their age range was 34 – 69 years. Five subjects had a right hemiparesis and 10 had a left hemiparesis.

PROCEDURE

Variables measured were:

- The time taken to walk in the middle 10 meters was measured with a stop watch
- Step length (Saleh and Murdoch 1985) (Step length is the distance between successive points of floor-to-floor contact of alternate feet.
- Stride length (Bogardh and Richards 1981) (Stride length is the distance between two consecutive ipsilateral foot contacts on a walking surface measured in meters.

These measurements were taken in the middle 10 meters of the 15 metre paper walk way. Step length and stride length were measured from the foot prints marked on the paper walkway. All measurements were taken first without the knee brace, then with the knee brace on the affected side. The means for time taken to walk, step length and stride length were then calculated.

A 15 meter length of paper was secured to the floor with press stick and marked with the subject's study number. Lines were drawn over the starting and finishing markers so that data could be collected from the central 10 meters with the first 2,5 meters

allowed for acceleration and the last 2,5 meters for deceleration.

Self adhesive ink pads were soaked in ink and were then attached to the subjects' shoes at the start of the paper walkway while they were seated on a chair. A triangular pad was attached to the toe and a square pad was attached to the heel (blue ink on the left and red ink on the right foot).

The subjects were asked to walk at their normal walking speed from one end to the other end of the paper walkway. The time taken to walk the middle 10 meters, was measured with a stop watch.

The knee brace was applied to the subject's hemiparetic knee and double locked into 20° knee flexion to prevent hyperextension but allowing free flexion movement.

Subjects were given a 30 minute rest and walk about to get used to the knee brace. During this time refreshments were served to the subjects.

A new 15 meter paper walkway was laid, secured and marked with the subject's number and the central 10 meters marked. The ink pads were re-applied and subjects were asked to walk again at a comfortable speed along the paper walk way.

- A structured interview was conducted after subjects walked with the knee brace to ascertain how the subjects felt about the brace. They were asked to indicate if the brace made their walk easy or difficult, or had no effect. The presence or absence of knee pain before and after the use of the knee brace was also recorded. Finally they were asked if they would recommend the use of the brace and when? i.e.

- 1) While still in the hospital.
- 2) On discharge.
- 3) When they have been walking for some time.

STATISTICAL ANALYSIS

Descriptive statistics, ie means and standard deviations, were used to summarise the observed data for the three gait parameters before and while wearing a knee brace. The outcomes of the three gait parameters observed while patients were not using a knee brace were compared with the outcomes that

were observed while wearing a knee brace using the student's paired t-test. Testing was also done using Wilcoxon's matched pairs sign rank test. In the event of a discrepancy the outcome of the latter was accepted if it were significant while the student's t-test was not, as a significant result is possible in small samples where data may be skewed. Testing was done at the 0.05 level of significance. The sample size of 15 patients gave 90% power to detect a change of one standard deviation.

RESULTS

There were ten male subjects and five

female subjects. There was a wide age range from 34-69 years (mean 51.3 years).

The period since the onset of stroke in these fifteen subjects varied between two months and 204 months. The mean period was 50.5 months. This is a possible limitation due to gait patterns having already been established. Five of the fifteen subjects had a right hemiparesis and ten had a left hemiparesis.

All fifteen subjects walked with an observable hyper-extended knee on the paretic side and were able to walk a distance of at least fifteen metres independently.

Table 1: Speed with and without FECK Brace

There was a significant difference between the speed of walking with and without the brace ($p = 0.05$).

The brace was always on the affected side.

Table 2: Step length with and without FECK Brace

There was no significant difference between the step length with or without the brace ($p=0.06$)

The brace was always on the affected side.

Table 3: Stride length with and without FECK brace

There was no significant difference between the stride length with and without the brace on either the right ($p=0.34$) or left leg ($p=0.18$)

The brace was always on the affected side.

Table 1: Speed with and without FECK Brace.

Speed (m/s)	Without Brace (n - 15)	With Brace (n - 15)
Mean Speed m/s	0.52 (± 0.28)m/s	0.54 (± 0.29)m/s
Minimum Speed m/s	0.17 m/s	0.18 m/s
Maximum Speed m/s	1.18 m/s	1.29 m/s

Table 2: Step Length with and without FECK Brace

Step Length (cm)	Without Brace (n = 15)		With Brace (n = 15)	
	Right Side	Left Side	Right Side	Left Side
Mean Step length (cm)	41.25 (± 12.17)	40.6 (± 13.51)	42.73 (± 12.18)	40.59 (± 12.9)
Minimum step length (cm)	26.87	20.36	24.77	22.49
Maximum step length (cm)	65.10	70.00	64.50	65.81

Table 3: Stride length with and without FECK brace

Stride Length (cm)	Without Brace (n = 15)		With Brace (n = 15)	
	Right Side	Left Side	Right Side	Left Side
Mean Stride length (cm)	79.74 (± 27.29)	79.17 (± 27.36)	83.04 (± 22.64)	81.84 (± 21.77)
Minimum step length (cm)	25.90	24.3	54.80	50.70
Maximum step length (cm)	135.40	134.95	126.76	126.80

Table 4: p-values of WMPRT and Student's paired t-test of Affected and Unaffected Leg

Mean Step/Stride Length (cm)	WMPRT p-value		Paired t-test p-value	
	Affected Leg	Unaffected Leg	Affected Leg	Unaffected Leg
Mean Step Length (cm)	0.75	0.97	0.39	0.77
Mean Stride Length (cm)	0.32	0.164	0.40	0.20

Figure 1: Subjects' Perceptions of the Brace.

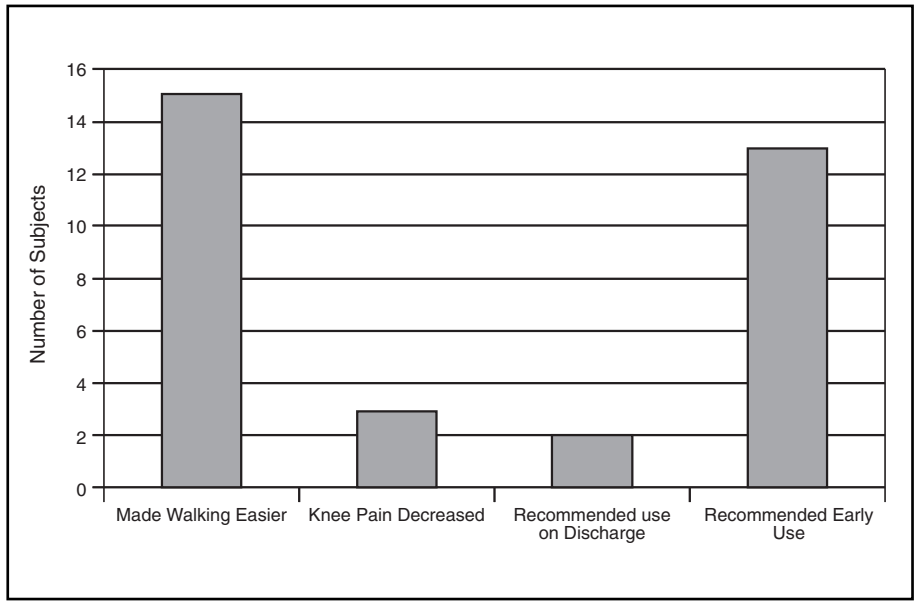


Table 4: p-values of WMPRT and student's paired t-test of affected and unaffected Leg

There was no statistical difference in the step length and stride length for both affected and unaffected leg with and without the use of the FECK brace on the affected side.

Figure 1: Subjects' perceptions of the brace

Fifteen subjects indicated that the brace made their walking easier. Three indicated that they always had knee pain while walking but the pain eased as they used the brace. All fifteen subjects recommended the use of the brace.

DISCUSSION

The results of this study show that, the use of the knee brace resulted in a statistically significant improvement in the speed of walking in subjects with hemiparesis.

Normal walking speed has been reported to range between 1.14 -1.69 m/s (Turnbull et al,1995). Riley et al (1996) considered speed over 1 m/s as normal in a stroke population.

In this study the slowest speed for subjects was 0.17 m/s without the brace and 0.18 m/s with the brace. There was thus an increase of 0.01 m/s. The speed of the older subjects also increased. The fastest subject walked at a speed of 0.18 m/s without the brace and 1.29 m/s with the brace. This subject's speed

without the brace falls within the lower range of normal speed. There was a marked increase in speed of 0.11 m/s velocity when he used the brace. As patient felt secure walking with the brace, this could be one of the reasons why the speed increased.

The mean speed for all fifteen subjects also shows that the speed increased significantly with the use of the brace. Although the significant increase in speed was only 0.02 m/s, this small change could possibly be clinically relevant in the population under study. This increase in speed may be enhanced with repeated use of the brace.

All 15 subjects said that the brace made their walking easier. They emphasised in several different statements as quoted:- "the brace supports/holds the leg", "it gives balance and support to the leg", "it increases knee control", "it increases balance of the leg and self confidence". The overall feeling of all subjects was that the knee brace gave support to the paretic leg and increased the subjects' self confidence in walking.

Eighty seven percent of subjects recommended that the brace be used when patients have had a stroke and are still in hospital and are ready to be mobilised because it made them move easier. This recommendation is supported by the statement of Turnbull and Wall (1989) that gait re-education commences on the first day post stroke. The use of the brace could be considered to have a

number of advantages. It allows early gait re-education. It also allows the ability to transfer weight through the affected lower limb. In addition three subjects had pain in the paretic knee. All three subjects reported that the knee pain decreased while using the knee brace

Lastly, using the brace provides an opportunity for gait to be practiced continuously as the brace temporarily support the affected knee during weight bearing phase. The length of time over which practice is continued is important (Turnbull and Wall,1989). Motivated subjects are more likely to walk which will in turn facilitate quadriceps muscle activity. The brace should not replace muscle control of the knee but may allow early weight-bearing as an adjunct to treatment while muscle control is being obtained. Given the short time patients spend in hospital, the use of a brace might be worth further investigation.

An increase in the step length while using the brace, was noticed in only seven subjects but step length did not change statistically as a result of using the brace.

A stride length of one metre or more is considered normal (Riley et al, 1996). In this study the stride of the twelve subjects was less than one metre, meaning that their stride length was shorter than that of normal subjects. Being a combination of two successive step lengths, stride length is directly affected by the step length measurements but does not show asymmetry of gait as does step length (Riley et al,1996). Since there was no significant improvement in the step length while using the brace the same applies to the stride length. Moreover as the stride length is dependent on the step length, the stride length is not a sensitive measurement for the evaluation of gait.

CONCLUSION

Patients walked faster using the FECK brace. There were no significant differences in stride length and step length. All patients recommended the use of the FECK brace. It is therefore recommended that this brace may be a beneficial adjunct to the gait retraining process and further investigation should be considered.

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