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Comparative analysis of leg posture in stroke patients with and without Ankle Foot Orthosis (AFO)

Amin Ahmed [1,*], Marzana Shelly [1], Rakib Mia [2], Maysha Binte Islam [2] and Amena Rahman [3]

[1] *Department of Prosthetics and Orthotics, Bangladesh Health Professions Institute (BHPI), The Academic Institute of Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka, Bangladesh.*
[2] *Prosthetics & Orthotics Department, Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka, Bangladesh.*
[3] *Department of Occupational Therapy, Bangladesh Health Professions Institute (BHPI), Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka, Bangladesh.*

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Abstract

Background: Stroke causes long-term disability with reduced joint Range of Motion (ROM), muscle spasticity, hemiparesis and abnormal gait. Ankle Foot Orthoses (AFOs) improve alignment and gait pattern in rehabilitation; however, few studies assess their combined effects on ROM, muscle spasticity and gait parameters in same subjects.

Purpose: To observe and describe changes in joint ROM, muscle spasticity and gait parameters among stroke patients using AFOs over 8 weeks.

Methodology: A multiple case within-subject repeated-measure observational study was conducted on 3 stroke survivors. Assessments were performed without AFO and at 0, 4 and 8 weeks of use. Joint ROM was measured by Goniometer, muscle spasticity by Modified Ashworth Scale (MAS) and gait parameters by Kinovea video analysis.

Results: Hip ROM (flexion, extension, abduction) increased over 8 weeks, while knee ROM remained stable. Ankle dorsiflexion improved in two subjects (5°→13°, 3°→11°) with slight improvement in one (6°→8°). Spasticity of plantarflexor decreased (MAS 2→1+) in two subjects, while one showed no changed; inversion spasticity (MAS 2) remained unchanged. Cadence improved in all participants (52→58, 48→55, 45→66 steps/min). Step and stride length showed variable but improved in Subject 3 (44.3→51.4 cm). Without AFO, excessive plantarflexion (25.6°-35.8°) resulted loss of heel rocker. AFO restored neutral alignment, enhancing heel strike and tibial advancement.

Conclusion: Rigid AFO use improved ankle dorsiflexion, decreased plantarflexor spasticity in some individuals, increased cadence and improved ankle alignment. Results varied among individuals, indicating proper orthotic prescription must be tailored to improve gait and posture of stroke patients.

Keywords: Stroke; AFO; ROM; Muscle spasticity; Leg posture; Stroke rehabilitation

1. Introduction

Stroke or cerebrovascular accident occurs due to the unsupplied blood flow to the brain, slowing its activity which in the long term can cause life threatening conditions. It is classified into two types: haemorrhagic, where there is a blood vessel rupture, and Ischemic, where arterial blockage occurs. Stroke is known to be a leading cause for both disability and mortality especially for less developed country (1). The haemorrhagic stroke is the result of broken blood vessels

* Corresponding author: Amin Ahmed.

and blood leakage outside the vessel, while ischaemic is due to obstruction of a blood vessel and the resulting damage to the brain tissue. Moreover, while both types reported hypertension as a common risk factor, ischaemic strokes were more likely to be linked to lifestyle factors (such as smoking) and alcohol consumption was more likely to be linked to haemorrhagic strokes (2).

Strokes drastically impact a person's motor skills, especially in controlling and walking with the lower limbs. Hemiparesis (weakness on one side of the body) and spasticity (muscle stiffness) of legs due to damage in the brain's motor control areas leads to disturbed gait (walking) patterns (3). Features of motor paralysis, spasticity, and impaired balance are characterized by reduced limb extension values, proportional limb shortening, and reduced effective limb length which are associated with gait disorders following stroke. (4).

In the world, stroke is one of the leading causes of death and disability, 11.9 million of stroke cases were incident, 93.8 million of stroke cases were prevalent and 7.25 million of people died due to stroke. Burden from stroke is unevenly distributed across Asia with East Asia having the highest burden and South Asia the lowest (5). The prevalence of stroke was 11.39 participants per 1000 people in a national survey and is one of the common causes of death in Bangladesh. The incidence of Type 2 diabetes in rural communities is much higher, 1.04-1.07 per 1,000 people (6).

Maintaining a proper posture of the legs is essential to balance, functional independence, recovery and recovery during stroke rehabilitation. Trunk exercises and hip strategy training enhances stroke rehabilitation of active leg posture (7). Comprehensive stroke physiotherapy programs targeting leg posture and balancing integrate physiotherapeutic techniques tailored for them and are crucial during stroke recovery (8).

An ankle foot orthosis (AFO) is a type of brace that provides support to the foot and ankle. It helps with rehabilitation following a stroke, such as foot drop and gait problems. The AFOs permit vertical and horizontal walking steps because of proper positioning of the foot in relation to the leg which is essential for stroke patients with hemiparesis (9). Ankle-foot orthoses (AFOs) can enhance posture, gait and balance in individuals with stroke by reducing abnormal muscle forces and active pathological movement of the ankle joint. They assist in active and appropriate movement of the ankle during designated phases of walking which help gait mechanics to reduce falling and tripping (10).

The comparison of patients with and without AFOs (ankle foot orthoses) is crucial for assessing patients' mobility and rehabilitation therapy goals. AFOs have been found to have a significant effect on gait dynamics. An increase in walking speed, energy expenditure reduction, and enhanced balance during both single and dual-task activities confirm this (11).

Numerous gaps exist in the current body of research on the use of ankle foot orthoses (AFOs) for stroke survivors, especially about the complex effects of leg posture during ambulation. Given the evidence that AFOs can facilitate walking speed and dorsiflexion angles, there is no in-depth discussion of how they impact upon a person's daily life or activities (12).

Stroke is one of the major causes of chronic disability in the world and leads to hemiparesis and substantial changes in motor control of the lower limbs. Measuring Joint ROM, spasticity and gait parameters can provide a numerical assessment of the impact of AFO on functional leg posture and walking ability in post stroke patients. This work therefore seeks to address a lack in the existing rehabilitation literature with a detailed report on the effect of AFO on leg posture and the ability of AFO to facilitate functional recovery in stroke survivors. The aim of this study is to assess and describes the effects on the range of motion, muscle tone and gait of stroke patients in AFOs within an 8-week period.

2. Material and methods

The research design employed for the study was within subject repeated measures design and the research method adopted for the study was observation approach. The effects of Ankle Foot Orthosis (AFO) on 3 purposively selected adult stroke patients that were capable of walking at the prosthetics and orthotics department, CRP, Savar were evaluated. The data were collected in both conditions (AFO and no-AFO) after 0, 4 and 8 weeks of AFO use between October 2025 and December 2025. By goniometer joint range of motion was measured, spasticity was assessed using Modified Ashworth Scale (MAS) and by using Kinovea software gait parameters were analysed through video recording. Data collected was analysed descriptively using excel software.

From Bangladesh Health Professions Institute (BHPI) Institutional Review Board ethical approval was obtained **(Reference number: CRP-BHPI/IRB/09/2025/1142)** and informed consent and confidentiality were ensured.

3. Results

The chapter presents the findings of the research using the information collected from three stroke patients who were prescribed ankle foot orthoses (AFOs). The results provide details of the changing lower limb joint range of motion (ROM), muscle spasticity and gait parameters in two conditions; without AFOs and with AFOs after a period of time. Implementing procedures were at baseline (no AFO) and 0, 4 and 8 weeks of AFO use.

3.1. Socio demographic and Clinical Characteristics of Participants

Table 1 Sociodemographic and Clinical Characteristics of Participants

Socio demographic information	Subject 1	Subject 2	Subject 3
Age	55 years	59 years	40 years
Sex	Male	Male	Male
Type of stroke	Haemorrhagic	Ischemic	Haemorrhagic
Side of body affected	Right side	Left side	Left side
Time since stroke onset	6-12 months	6-12 months	6-12 months
Type of AFO	Solid AFO	Solid AFO	Solid AFO
Average AFO wear per day	5 hours	6 hours	6 hours
Therapy intervention	Physiotherapy	Physiotherapy	Physiotherapy
How long receiving therapy	4 months (ongoing)	7 months (ongoing)	5 months (ongoing)

This study involved three male stroke patients, age range 40-59. Two of them had haemorrhagic strokes and one ischemic, while two had affected left side and one right side. All three use solid AFO per day average 5-6 hours and with ongoing physiotherapy.

3.2. Changes in Lower Limb Joint Range of Motion (ROM)

Table 2 Changes in Lower Limb Joint Range of Motion (ROM)

Joint	Movement	Without AFO			With AFO (0 weeks)			With AFO (4 weeks)			With AFO (8 weeks)		
		Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3
Hip	Flexion	124°	125°	126°	124°	125°	126°	130°	127°	130°	133°	131°	133°
	Extension	16°	15°	14°	16°	15°	14°	19°	16°	17°	22°	23°	19°
	Abduction	21°	20°	39°	21°	20°	39°	30°	29°	39°	32°	31°	43°
	Adduction	13°	10°	18°	13°	10°	18°	15°	13°	18°	18°	15°	20°
	Internal rotation	21°	13°	22°	21°	13°	22°	23°	15°	23°	23°	18°	23°
	External rotation	35°	30°	24°	35°	30°	24°	34°	32°	24°	36°	36°	30°
Knee	Flexion	128°	135°	121°	128°	135°	121°	130°	136°	126°	134°	136°	132°
	Extension	0°	0°	0°	0°	0°	0°	0°	0°	0°	0°	0°	0°
Ankle	Dorsiflexion	6°	5°	3°	6°	5°	3°	7°	11°	6°	8°	13°	11°
	Plantarflexion	41°	45°	39°	41°	45°	39°	43°	44°	40°	47°	45°	44°
	Inversion	16°	17°	18°	16°	17°	18°	19°	20°	17°	20°	20°	19°
	Eversion	3°	0°	2°	3°	0°	2°	3°	2°	2°	3°	3°	3°

According to table-2, the most improvement seen at ankle joint, dorsiflexion ROM improved maximum in subject 2 and 3, while subject 1 showed less improvement. At the hip joint, there were gradual changes in flexion, extension, and abduction that all the subjects showed throughout the 8-week period. ROM of knee joint did not change significantly during the study.

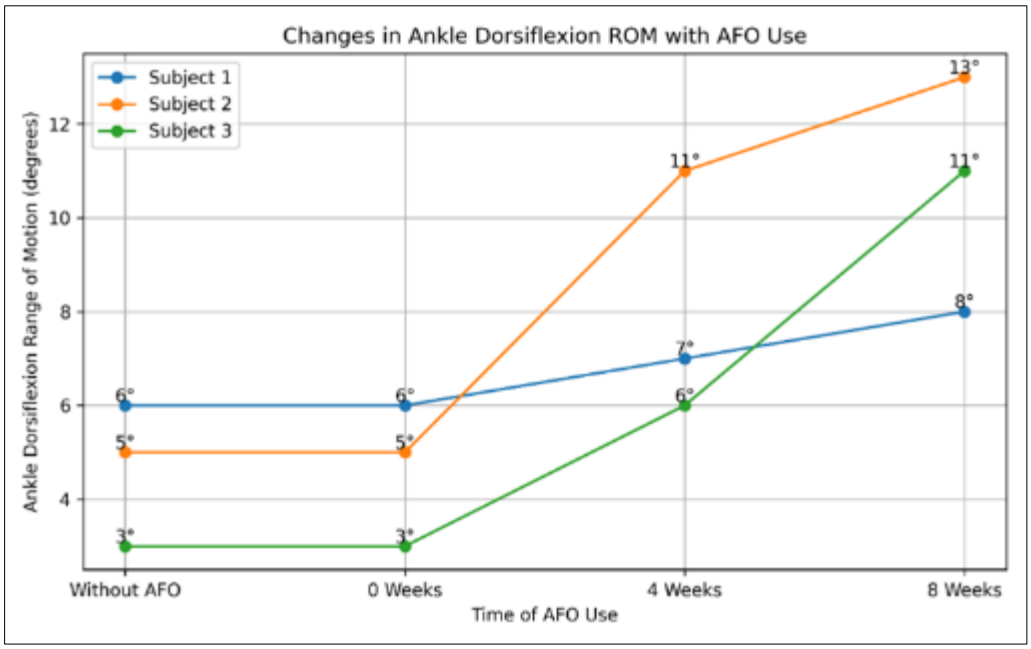

Figure 1 Changes in Ankle Dorsiflexion ROM with AFO Use

3.3. Changes in Muscle Spasticity (MAS)

Table 3 Changes in Muscle Spasticity (Modified Ashworth Scale)

Joint	Movement	Without AFO			With AFO (0 weeks)			With AFO (4 weeks)			With AFO (8 weeks)		
		Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3
Hip	Flexion	0	0	0	0	0	0	0	0	0	0	0	0
	Extension	0	0	0	0	0	0	0	0	0	0	0	0
	Abduction	0	0	0	0	0	0	0	0	0	0	0	0
	Adduction	0	0	0	0	0	0	0	0	0	0	0	0
	Internal rotation	0	0	0	0	0	0	0	0	0	0	0	0
	External rotation	0	0	0	0	0	0	0	0	0	0	0	0
Knee	Flexion	0	0	0	0	0	0	0	0	0	0	0	0
	Extension	0	0	0	0	0	0	0	0	0	0	0	0
Ankle	Dorsiflexion	0	0	0	0	0	0	0	0	0	0	0	0
	Plantarflexion	2	2	2	2	2	2	2	2	2	2	1+	1+
	Inversion	2	2	2	2	2	2	2	2	2	2	2	2
	Eversion	0	0	0	0	0	0	0	0	0	0	0	0

According to table-3, after eight weeks of wearing the AFO, a significant reduction in the plantarflexor spasticity was found in two out of three of the subjects (Subjects 2 and 3) whose MAS scores fell to 2 to 1+. Conversely, Subject 1 showed no indication of change in plantarflexor spasticity with MAS grade being 2 at the time of the study.

3.4. Changes in Gait Parameters

Table 4 Changes in Gait Parameters

Gait parameter	Without AFO			With AFO (0 weeks)			With AFO (4 weeks)			With AFO (8 weeks)		
	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3
Step Length (first)	25 cm	11 cm	28.7cm	28.8cm	7.8 cm	24.7cm	31.3cm	14.3cm	23 cm	21.9cm	15.6cm	27.5 cm
Stride Length (first)	48 cm	41.2 cm	44.3cm	41.2cm	36.5cm	41.2cm	52.2cm	52.4cm	50 cm	43.7cm	44.5cm	51.4 cm
Cadence	52	48	45	54	50	49	54	51	60	58	55	66
Foot Clearance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(Cadence= steps/minute)

Table-4 shows that there was general improvement in Cadence (steps/minute) over time for all subjects. Step length varied from subject to subject on the different subjects. The length of stride increased at 4 weeks in all subjects with AFO intervention over baseline, indicating the early mechanical benefits of AFO intervention. Further, the clearance at the bottom of the foot was kept adequate in all cases.

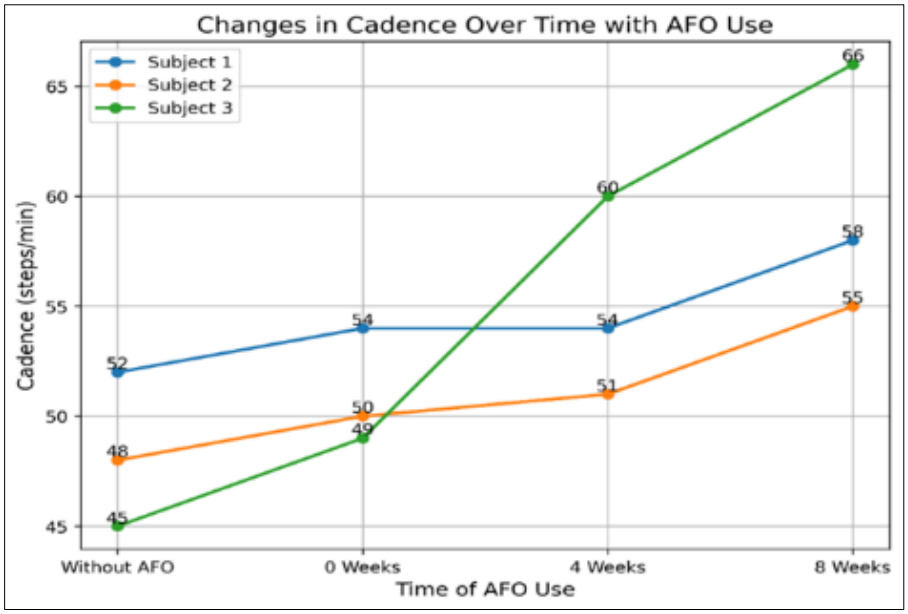

Figure 2 Changes in Cadence Over Time with AFO Use

3.5. Joint Angulation During Gait Cycle

Table 5 Joint Kinematics During Gait Cycle

Gait Phase	Joint	Without AFO			With AFO (0 weeks)			With AFO (4 weeks)			With AFO (8 weeks)		
		Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3	Sub 1	Sub 2	Sub 3
Initial Contact	Hip	12.5°F	5.5°F	8.8°F	16.3°F	12.8°F	11.8°F	20.2°F	11.1°F	13.6°F	5.6°F	5.4°F	13.6°F
	Knee	13.5°F	5.3°F	1.7°E	13.9°F	11.5°F	10.1°F	15.1°F	19.5°F	6.3°F	4.6°F	11.4°F	5.7°F
	Ankle	25.6°P	35.8°P	28.3°P	N	N	N	N	N	N	N	N	N
Loading Response	Hip	10.2°F	4.3°F	5.6°F	15.3°F	6.1°F	4.5°F	18.6°F	7.4°F	9.2°F	2.1°F	4.1°F	12.1°F
	Knee	8.6°F	6°F	2.4°E	23.9°F	8.7°F	9.7°F	20.4°F	7.4°F	9.4°F	2°E	11.1°F	12.4°F
	Ankle	18.6°P	30°P	31.6°P	N	N	N	N	N	N	N	N	N
Mid Stance	Hip	13.7°F	1.1°F	2.2°F	6.7°F	3.2°E	0°	6.7°F	1.7°E	2.1°F	3°E	5.5°E	0°
	Knee	23.4°F	0°	0°	0.3°F	3.9°E	0°	0°	1.5°E	4.9°F	1.5°F	1.5°E	1°F
	Ankle	8.3°P	10.8°P	7.9°P	N	N	N	N	N	N	N	N	N
Terminal Stance	Hip	2.7°F	2.2°E	7.1°E	3.9°F	1.7°E	4.7°E	10.6°E	9°E	1.7°E	2.9°F	11.4°E	4.2°E
	Knee	33°F	4°F	7.3°F	11.8°F	13°F	4°F	1°F	0.3°E	10.5°F	5.7°F	1.3°E	14°F
	Ankle	3.2°P	19.5°P	7.4°P	N	N	N	N	N	N	N	N	N
Pre Swing	Hip	6.4°F	0.4°F	7.4°E	4.7°F	7.7°F	3.1°E	13.7°E	2.5°F	1.3°F	5.9°F	7.6°F	6.5°F
	Knee	39.2°F	12.9°F	10.8°F	17.1°F	22°F	9.2°F	12°F	24.5°F	15.9°F	18°F	17.2°F	23.5°F
	Ankle	19.2°P	23.8°P	3°P	N	N	N	N	N	N	N	N	N
Initial Swing	Hip	11.6°F	6.9°F	5.2°F	7.2°F	5.8°F	5.4°F	15.6°F	9.5°F	6.3°F	9.8°F	9.8°F	7.1°F
	Knee	51.6°F	22.8°F	11.1°F	25.6°F	30.5°F	14.4°F	41°F	34.9°F	8.5°F	33.6°F	31.1°F	25v
	Ankle	36°P	36.5°P	16.6°P	N	N	N	N	N	N	N	N	N
Mid Swing	Hip	20°F	14.8°F	2.4°F	7.3°F	9.4°F	0°	16.4°F	7.8°F	6.7°F	9.3°F	12°F	10.5°F
	Knee	42.3°F	18.1°F	8.3°F	30.5°F	18.1°F	8.4°F	39.7°F	15.1°F	7.7°F	23.8°F	21.4°F	13.6°F
	Ankle	33.4°P	25.4°P	12.7°P	N	N	N	N	N	N	N	N	N
Terminal Swing	Hip	12.4°F	11.9°F	12.1°F	5.9°F	8.3°F	14.6°F	24.4°F	11.6°F	13.4°F	23.8°F	7.6°F	14.9°F
	Knee	3.1°F	8.5°F	1°E	9.6°F	13.4°F	9°F	19.3°F	14.7°F	10.6°F	11.4°F	14.4°F	14.9°F
	Ankle	40.7°P	26.7°P	31.2°P	N	N	N	N	N	N	N	N	N

(F= Flexion, E= Extension, P= Plantarflexion, N= Neutral position of the joints)

According to table-5, ankle angles at heel-strike period during initial contact with the ground were in excessive plantarflexion of Subjects 1, 2, and 3 respectively, indicating that there was no functional heel rocker. This was corrected by immediately applying the AFO at the baseline assessment (0 weeks) and continued to be corrected through a neutral (N) position of the ankle joint at all weight-bearing, or stance phases. Compensatory strategies were however more varied, and the rotational adjustment of the hip and knee joints which are more proximate were more heterogeneous and individualized.

4. Discussion

The findings of this study showed that the use of ankle foot orthosis (AFO) produced significant subject specific improvements in lower limb biomechanics, joint ROM, muscle spasticity, gait parameters and gait phase kinematics over 8 weeks of AFO use. There is individual variation in response, with subjects 2 and 3 showing the greatest ROM improvements with ankle dorsiflexion moving from 5° and 3° to 13° and 11° respectively, with subject 1 improving

slightly from 6° to 8° for dorsiflexion. These findings are reinforced by previous studies which have found that AFOs have a beneficial effect on distal joint mechanisms by keeping the ankle in neutral position, preventing joint contracture and also having a beneficial effect on proximal joint mobility indirectly (13, 14). In subject 2 and 3 the plantarflexor spasticity was reduced from MAS grade 2 to 1+, whereas no reduction was seen in subject 1, indicating that the reduction of plantarflexor spasticity was dependent on stroke severity, baseline plantarflexor spasticity of the subjects and on their neuromuscular adaptability (15,16). In all three subjects, cadence increased in all subjects, and stride length increased in all subjects, both at early time and maintaining foot clearance which demonstrated improved gait parameters, but there was a decrease in some parameters at week 8 indicating fatigue on orthotic support (17,19). Excessive plantarflexion at initial contact (25.6°-35.8°) was corrected to neutral during stance and heel rocker and controlled tibial progression was restored (12,17,18,20). Overall, AFOs proved to be effective for improving ankle ROM, reducing plantarflexion muscle spasticity, improving gait parameters and gait correction but effectiveness of AFOs was greatest when they were prescribed individually and were combined with gait training, strengthening and stretching. There are several limitations that this study has. Limited generalization is the result of small sample size. Only solid AFOs were studied, so results will not be applicable for other designs. It is hard to differentiate AFO effects since physiotherapy continues in subjects. Long term effects may not be seen in 2D video analysis or follow up as compared to 3D video analysis and follow up. Larger samples should be studied in the future. Varied types of AFOs to find best prescription for stroke patients. Long term outcome and adaptability is to be assessed with longer follow up. Patients with AFO should be treated with the orthosis only and 3D gait analysis should be emphasized.

5. Conclusion

This study shows how using AFOs affects ROM, muscle spasticity and gait in 3 stroke patients over 8 weeks. The greatest improvements occurred at ankle with two subjects improving dorsiflexion ROM and knee showing no change. There was minimal improvement in hip joint. In two subjects, plantarflexion spasticity decreased, and in one, it did not, thus indicating that this is subject dependent. All subjects showed improvement in cadence and stride length improved for 4 weeks. The AFOs corrected excessive plantarflexion to achieve neutral position at the ankle to provide a safer gait. The small sample size in this study does not preclude the conclusions, however, and suggests that regular AFO application along with physiotherapy can be beneficial in chronic stroke rehabilitation.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflicts of interest with respect to the research, authorship, or publication of this article.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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