INTERVENTION FOR FOOT DROP IN A PATIENT WITH SUBACUTE STROKE:

A CASE REPORT

A Case Report Presented to

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Doctor of Physical Therapy

By

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This case report is submitted in partial fulfillment of
the requirements for the Degree of
Doctor of Physical Therapy

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The final copy of this case report has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.
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Abstract

Gait deviations are a common deficit seen in persons with stroke. The purpose of this case report was to compare and describe the use of Ace© wrap bandaging and a posterior leaf spring ankle foot orthosis (AFO) as an intervention for the treatment of foot drop in a patient with subacute stroke. The case patient suffered a stroke in the right pons resulting in left hemiparesis and 2+/5 strength in the left ankle dorsiflexors as measured by manual muscle testing (MMT). The patient was instructed to ambulate 10 meters at his usual pace with a two-wheeled rolling walker. Three trials of gait training were performed; first without the use of any dorsiflexion assistance, second while wearing a posterior leaf spring AFO, and a third time while utilizing Ace© wrap bandaging. Measures of patient performance included the gait section of the Tinetti Performance Oriented Mobility Assessment (POMA), gait velocity, cadence, and joint positioning at the trunk, the hip, and the knee assessed by the “Coaches Eye” Video Analysis software. The patient demonstrated a 2 point increase in the Tinetti gait score, improved joint positioning, a 29.4% increase in gait velocity, and a 16% increase in cadence while utilizing the elastic wrap bandaging in comparison to the results from the first gait trial, without any dorsiflexion assistance. With the posterior leaf spring, the patient demonstrated a 2 point decrease in the Tinetti gait score, poorer joint positioning, a .06% decrease in gait velocity, and no change in cadence when compared to the results from the first gait trial. This case patient performed best with the use of Ace© wrap bandaging during ambulation. Further study is needed to determine if this is consistent with the broader population of stroke survivors.
Introduction

A stroke is a cerebrovascular accident that results in the reduction of the brain’s blood flow causing destruction to surrounding brain tissue (Goodman & Fuller, 2008). A stroke occurs when blood flow to the brain is interrupted due to obstruction within a blood vessel (ischemic) or from a weakened vessel that ruptures (hemorrhagic) allowing blood to accumulate and compress the brain tissue (McArdle, Katch, & Katch, 2009). With a stroke, damage can occur where nerve fibers are highly condensed along the upper motor neuron tracts. This can include the motor cortex, corona radiata, internal capsule, cerebral peduncle, medulla, and pyramidal tract of the spinal cord (Westhout, Pare, & Linskey, 2007). It is typical to see muscle weakness, loss of active range of motion, abnormal muscle tone, decreases in motor coordination, and decreases in reaction times in individuals who have suffered a stroke (McArdle et al.). Foot drop is the result of a weak tibialis anterior muscle and can result as a complication of stroke. It is estimated that foot drop occurs in 20% of individuals following a stroke (Ring, Treger, Gruendlinger, & Hausdorff, 2009). The inability to completely lift the foot (due to foot drop) during the swing phase of the gait cycle can result in gait deviations. Cognitive function, sensory organization, and multisensory integration also play a role in influencing postural control, and damage to these systems can contribute to walking impairments (De Oliveira, De Medeiros, Frota, Greters, & Conforto, 2008).

Stroke Rehabilitation

Stroke rehabilitation focuses on regaining strength and movement in the affected extremities, and much research has been devoted to restoring lower extremity function. Loss of motor control from the brain results in the inability to control movement of the trunk, the upper extremities, or the lower extremities depending on the location of the lesion. In addition, there is loss of muscle tone that contributes to muscle weakness and loss of coordination and postural
control when walking. In addition to motor control, adequate postural control during gait requires the integration of information from three main sensory systems: somatosensory, visual, and vestibular (De Oliveira et al., 2008). In individuals with stroke, abnormal interactions between the three sensory systems may result in inadequate postural control and compensatory motions during gait in an effort to maintain their balance. Although the role of each of these systems is important, there is evidence that the somatosensory system is the primary contributor of feedback for postural control during gait. Individuals who have had a stroke may inappropriately rely on one system over another in situations where a sensory conflict is present. It is common for individuals with stroke to experience the loss of ankle reflexes, the loss of proprioception, the loss of vibration and light touch, and the loss of sensory input during movement which can result in the inability to maintain postural stability, contributing to altered gait patterns, and an increased risk of falling (De Oliveira et al.).

The ability to walk is one of the most important goals in stroke rehabilitation (Nilsson et al., 2001). Loss of balance and decreased ankle proprioception are major impairments in individuals with stroke and are major causes of instability and falls in this population (De Oliveira, 2008). Approximately 75% of stroke survivors will have a fall within the first 6 months after a stroke (Goodman & Fuller, 2008). Walking is the most frequently cited activity (as high as 90%) in this population at the time of a fall (Weerdesteyn, de Niet, van Duijnhoven, & Geurts, 2008). Considering the high fall incidence rates that occur during walking, it is no surprise that emphasis on early rehabilitative interventions in gait training is recognized as beneficial for improving dynamic balance, mobility, and functional independence (Franceschini, Carda, Agosti, Antenucci, Malgrati, & Cisari, 2009).
Ankle Foot Orthotics

Evidence suggests that rehabilitation and/or assistive devices may be required to correct foot drop. During musculoskeletal simulations, normal gait patterns could not be attained when any one of the three muscle groups: the dorsiflexors, the plantarflexors, or the hamstrings, were impaired. To recreate normal gait pattern, the model required muscle activation to reach at least 64%, 55%, and 18% respectively when the individual muscle groups were impaired (Knarr et al., 2012). Individuals with severe motor impairments of the paretic leg employ compensatory strategies that consist of asymmetric weight bearing postures. (Roerdink, Geurts, De Haart, & Beek 2008). These typically include trunk lean, hip circumduction, increased hip flexion, and increased knee flexion, especially when weakness in dorsiflexion is present. Studies have also found that individuals with hemiparesis show delayed initiation and execution of compensatory stepping reactions following a perturbation and are often unable to initiate these reactions with the affected limb (Inness et al., 2011). A case report by Mansfield et al., reported that perturbation training increased the use of the affected limb and resulted in faster stepping reactions in their subject. These enhancements reflect improvements in control of the stance limb and the swing limb. The study concluded that training can improve the efficacy of these stepping reactions and decrease the risk of falls (Mansfield et al., 2011).

Assistive devices, such as ankle foot orthotics (AFOs) are an integral component of gait rehabilitation and are frequently prescribed for individuals with stroke who have balance deficits and limited mobility (Hesse, 2002). The primary purpose of an AFO is to provide support at the ankle by placing the ankle and the foot in a neutral position when the tibialis anterior is unable to provide dorsiflexion. AFOs help to clear the foot from the ground during the swing phase of gait,
stabilize the ankle during the stance phase of gait, and prevent spraining the ankle due to unintended inversion of the ankle during heel strike (Hesse, 2002).

Many studies have shown that when wearing AFOs, individuals with stroke walk faster and more efficiently. More specifically AFOs have been shown to improve gait parameters such as velocity, symmetry, and foot clearance during swing, while decreasing the amount of energy required by individuals with stroke when walking (Hesse, 2002). The literature also suggests that AFOs may play a role in influencing tactile and proprioceptive mechanisms in the lower legs by increasing feedback from cutaneous receptors in the foot and ankle (Aruin, 2010). This aids in proper ankle positioning and balance during gait, both of which help to reduce the risk of falls. A study by Abe, Michimata, Sugawara, Sugaya, & Izumi (2009) showed that wearing a plastic AFO resulted in significantly increased walking speed in individuals with stroke, when compared to walking without it. Furthermore, increased cadence, step width and stride length in both lower extremities were also noted, indicating that gait stability, in addition to walking speed also improved. Similar results were seen by Wang, Lin, Lee, and Yang (2007), who noted increases in step length on the unaffected extremity, and improvement in walking speed of the participants with hemiparesis. The results of these studies suggest that providing stability at the ankle joint promotes walking security in individuals with foot drop.

Muscle strength plays an important role in gait. Adequate strength, particularly in the triceps surae, the tibialis anterior, the rectus femoris, and the biceps femoris allows for smooth, uninhibited movements during the gait cycle. A study by Abdullah, Abu-Osman, and Abdul (2008) looked at the EMG activity of individuals with foot drop resulting from a brain injury. The results demonstrated that when participants wore a polypropylene AFO, they were able to compensate for weakness in the dorsiflexor muscles of the affected limb, as demonstrated by
equal and symmetric muscle activation of the gastrocnemius, the soleus, the rectus femoris and the biceps femoris in both the affected and the non-affected limb. The AFO helped to stabilize the ankle complex to reduce excessive and uncontrolled motions at the ankle, allowing for toe clearance and maintaining proper foot placement during heel strike.

**Neuromuscular Electrical Stimulation**

Neuromuscular electrical stimulation (NMES) is another intervention that has been widely used in the correction of foot drop in individuals with stroke. NMES involves the application of electrical impulses to stimulate lower motor neurons to assist in muscle contractions. In particular, the stimulation of the deep and superficial fibular nerve, either externally through electrodes positioned on the surface of the skin, or internally through surgically implanted electrodes, elicits a motor response in the ankle dorsiflexor muscles (Chae, 2003). It has been used to regain voluntary muscle contraction, improve the strength of the contraction, and prevent muscle spasticity. One of the earliest studies by Lieberman et al. (1961) documented that motor relearning is possible, with participants actively dorsiflexing the foot themselves after training with NMES (Chae, 2003).

The use of NMES is often timed with the swing phase of the gait cycle in individuals with foot drop to stimulate the tibialis anterior and the fibularis muscles to contract and produce a coordinated movement pattern (IJzerman, Renzenbrink, & Geurts, 2009). Improvements in walking ability have been well documented in individuals post-stroke with the use of NMES. In people with both acute and chronic stroke, an increase in walking speed, cadence, step and stride lengths, and ankle joint range of motion were noted when NMES was used in combination with conventional physical therapy (Sabut, Sikdar, & Kumar, 2011). In addition, decreased energy expenditure was also reported in individuals post-stroke when training with NMES.
Yan, Hui-Chan, & Li (2006) investigated the effects of NMES on walking ability in people with acute stroke. Participants were assigned to either a NMES group, a placebo group, or a control group. It was found that after three weeks of treatment, 85% of participants in the NMES group were able to walk with the help of an assistive device, compared to 60% of participants in the placebo group and 46% of participants in the control group. After fifteen sessions of therapy over the course of three weeks, approximately 85% of participants in the NMES group were discharged home, in comparison with those in the placebo group and control group at 53% and 46% respectively. Muscle spasticity of the plantarflexors was also assessed. A decrease in spasticity with participants in the NMES group was noted, while no significant differences were found between the placebo group and the control group, demonstrating the absence of any placebo effects (Yan, et al. 2006). Similar results were seen in a study by Sabut et al (2011). EMG activity of the tibialis anterior with the NMES showed significant increases in muscle strength when compared to the control group (56.6% and 27.7% respectively). In addition, spasticity in the gastrocnemius and soleus muscles were reduced by 38.3% and 21.2% respectively (Sabut et al., 2011).

Kluding et al. (2013) investigated the differences in recovery outcomes between gait training with an AFO and training with NMES in participants three months post-stroke or longer. Participants were randomized to 30 weeks of using either NMES (treatment group) or a standard AFO (control group). Thirty weeks into the study, the control group switched to NMES for an additional 12 weeks of observation. The treatment group continued using the NMES (Klundig, et al. 2013). Outcome measures in gait speed, functional mobility, walking endurance, and balance were obtained at baseline, at 6 weeks, at 12 weeks, and at 30 weeks. All outcome measures had similar patterns of change, with significant improvements noted within both groups but no
significant differences between the two groups. Even after 30 weeks, both groups continued to make significant gains in each of the outcome measures. However, there were no differences in outcome between the two groups. Ultimately, both the use of an AFO and NMES were effective interventions in stroke recovery.

The use of NMES has been demonstrated to improve lower extremity function in people post-stroke sooner than with conventional physical therapy. More participants were able to ambulate sooner when training with the NMES and more participants were discharged home sooner. The increase in dorsiflexor strength and the decrease in plantarflexor spasticity with the NMES is an important component in gait recovery. Greater recovery with NMES is evidenced by long term results with improvements in muscle spasticity and voluntary ankle dorsiflexion (Chae, 2003).

**Treadmill Training**

Many studies have looked at treadmill training as a promising method in restoring walking function in individuals post-stroke with hemiplegia. Outcomes commonly assessed include walking speed, endurance, balance, motor recovery, stride length and cadence, and functional walking (Barbeau & Visinton, 2003). Significant recovery outcomes using treadmill training have been evidenced in individuals post-stroke when compared with conventional over-ground gait training. Laufer, Dickstein, Chefez & Marcovitz (2001) demonstrated that treadmill training was well tolerated by individuals post-stroke in the early stages of gait rehabilitation. Participants who received therapy less than three months after a stroke occurred had improvements in gait pattern and walking ability with treadmill training. The findings suggested that treadmill training is more effective than conventional over-ground training for improving
gait parameters, such as ambulation, stride length, and gastrocnemius muscle activity (Laufer, et al. 2001).

Positive outcomes with treadmill training with the use of body weight support (BWS) on people with hemiplegia following a stroke have also been well documented. A harness is used to support a percentage of the patient’s body weight while retraining gait on a treadmill. Partial weight support removes some of the biomechanical and equilibrium constraints of full weight bearing, while walking on a treadmill is facilitated by the activation of the spinal locomotion centers (Laufer et al., 2001). Thus, BWS treadmill training can start before patients are able to fully bear weight. Individuals who utilize BWS treadmill training post-stroke rely on proprioceptive feedback transmitted from their joints to the spinal locomotion center of the spinal cord as they re-develop connections in the motor cortex for adequate motor control. This allows weight bearing, stepping, and balance to be trained simultaneously while the patient is walking on the treadmill (Nilsson et al., 2001). In a 2003 study comparing outcomes, subjects who received BWS treadmill training scored significantly higher in walking speed, endurance, balance, and motor recovery than those with full weight-bearing treadmill training (Barbeau & Visinton, 2003). Subjects with greater gait impairments, as determined by baseline measures, made larger gains in training with BWS, as did older individuals (65–85 years old) post stroke in comparison to those with lesser impairments, and those who were younger. Retraining gait in subjects post-stroke with a percentage of their body weight supported resulted in better over-ground walking outcomes than gait training subjects bearing full weight on a treadmill.

In a 2009 study, subjects with stroke showed improvement in physical functioning and activities after 6 weeks of BWS treadmill training; however, there were no differences in improvement between those who received BWS treadmill training to those who received
conventional over-ground training (Franceschini et al., 2009). BWS was initially set at 35% for these subjects and gradually reduced, over a period of 4 weeks, to 10% at the last session. Parameters measured in the study included: strength of the lower extremity, trunk control, lower limb spasticity, and proprioception. The study concluded that training on a treadmill with BWS was an effective intervention in regaining walking function; however, it was not superior to conventional over-ground training.

A study by Ada, Dean, Morris, Simpson, & Katra (2010) found that subjects post-stroke who received BWS treadmill training achieved independent walking two weeks earlier than those who received over-ground training (72% vs. 60% respectively). In addition, “subjects walked faster, further, and with longer stride at 6 months”. A follow-up of the same study determined that despite spending the same amount of time in physical therapy, subjects with stroke receiving BWS treadmill training practiced walking more than those training over-ground. The researchers concluded that walking on a treadmill differs biomechanically from walking over-ground. (Ada et al. 2010). Similar results were seen in a study by McCain et al, who concluded that by incorporating treadmill training in rehabilitation, patients with acute stroke were able to walk further and faster than those who only received conventional gait training after 6 months of therapy (McCain et al., 2008). In addition, better gait symmetry was seen in those who received treadmill training compared to subjects who received conventional gait training. For all 7 subjects in the treadmill group, the BWS was initially set at 30%, and gradually reduced to 5% in subsequent sessions. Treadmill training was used throughout the entire course of rehabilitation, while subjects in the control group received conventional gait training. All subjects in the treadmill group were able to achieve full weight bearing on the treadmill within the course of six months. The Six Minute Walk Test was used as an objective measure to
determine improvements in gait kinematics. A motion capture system recorded the gait of all the subjects and reflective markers were placed bilaterally at key landmarks on the lower extremity to analyze gait symmetry. Although subjects were allowed to use AFOs and assistive devices, none of the subjects in the treadmill group used an AFO or assistive device for the test. Four out of the seven subjects in the control group required devices for the test (McCain et al.).

Combined effects of treadmill training and conventional over-ground training have also been studied in patients with acute stroke. The research is promising in the recovery of gait. A 2004 study demonstrated that partial BWS treadmill training in addition to over-ground ambulation is more effective than over-ground ambulation alone in increasing walking speed and walking distance (Eich, Mach, Werner & Hesse, 2004). Similar results were obtained in a study by Venkadesen & Kumar (2011), noting greater improvements in cadence and stride length in subjects who underwent both types of training compared to over-ground training alone. A study conducted by Puh & Baer (2009) concluded that using a treadmill in conjunction with over-ground walking may be helpful in improving the gait pattern in patients post-stroke. Puh & Baer noted greater symmetry in the alternating movements of the limbs of the subjects when walking on the treadmill.

In a single case study design, Lindquist et al. (2007) compared the effects of the combined use of NMES and partial BWS treadmill training with the effects of partial BWS training alone in subjects with chronic hemiplegia following a stroke. Researchers assessed walking function, specifically gait speed, cadence, stride length, and motor function, through the Stroke Rehabilitation Assessment of Movement (STREAM) scale. Over the 9 weeks of rehabilitation, subjects participated in an A1-B-A2 training paradigm, where in phase A1 and A2, subjects underwent BWS treadmill training and in phase B, subjects underwent treadmill training
in combination with NMES applied to the fibular nerve. Each phase of training lasted 3 weeks. These researchers did not find any significant changes in walking function in subjects after phase A1. However, a significant increase in motor function was found after Phase B. Gait speed and cadence improved after phase B, with no significant changes in stride length. No significant changes in motor function were found between phase B and phase A2. In addition, subjects reported that “gait training during phase B was more comfortable because it was easier to position the foot during the early stance phase of gait”. The study concluded that 3 weeks of treadmill training with BWS combined with NMES yielded better results than BWS treadmill training alone (Lindquist et al.).

Positive outcomes have been seen using BWS treadmill training in restoring gait pattern. The ability of individuals post-stroke to walk further and faster can be attributed to the use of BWS in individuals post-stroke. Although the above studies have not commented specifically on the recovery of foot drop in subjects with stroke, it can be inferred that improvements in gait parameters such as walking speed, cadence, step length, and stride length are correlated with improvements in heel strike. Additional research is needed to determine the effects of BWS treadmill training on heel strike in individuals post-stroke and to determine its effectiveness as a treatment intervention in the recovery of foot drop.

Kinesiotape®

Another alternative intervention in managing foot drop in individuals with stroke is the application of Kinesiotape® on the surface of the tibialis anterior muscle. Although not as widely studied, evidence does suggest that it shows promise in motor recovery. Clinical uses of Kinesiotape® include correcting joint positioning, increasing proprioception, and increasing or inhibiting muscle recruitment which may assist in improving foot drop in individuals following a
stroke. (Lazarus, 2013). A study by Szczegielniak et al. (2012) investigated the effects of Kinesiotape® application to the tibialis anterior in correcting foot drop in 30 individuals 10 months post-stroke. Three trials were recorded. The subjects performed the 100 meter walk test one day before Kinesiotape® application, one hour after Kinesiotape® application, and 24 hours after Kinesiotape® application to correct foot drop. After Kinesiotape® application, a significant increase in gait speed was seen. Subjects required significantly less time to walk 100 meters with each consecutive trial. Prior to KinesioTape® application, subjects averaged 3 minutes and 46 seconds to cover the 100 meter distance. An hour after KinesioTape® application, the average time to cover the distance was 3 minutes and 29 seconds. Twenty four hours after KinesioTape® application, the time to cover the same distance was further reduced and the mean value obtained was 3 minutes and 16 seconds. Significant differences were seen in the time it took the subjects to cover the distance before KinesioTape® application, one hour after application, and 24 hours after application (Szczegielniak, et al., 2012).

Elastic Wrap Bandaging

No research articles were found in a search of the literature concerning elastic wrap bandaging as a treatment intervention for foot drop; however, elastic wraps are frequently used in the clinical setting to assist with dorsiflexion during early gait training. The purpose of this case report was to compare and describe the immediate effects between elastic wrap bandaging and a posterior leaf spring AFO on gait kinematics and joint angles in a patient with subacute stroke and subsequent hemiparesis.

Case Description

The patient was a 72 year old male who presented with left sided hemiparesis due to a stroke in the right pons. Rehabilitation began two days following the stroke consisting of
conventional physical therapy including range of motion exercises, strengthening exercises, and gait training with a rolling walker. The patient had a total of seven 1.5 hour therapy sessions since admission to the rehabilitation hospital.

*Initial Evaluation and Past Medical History*

Initial chart review revealed that the patient was admitted to the acute care hospital and diagnosed with “Right pons CVA with left hemiparesis”. Once medically stable, he was referred to inpatient rehabilitation 2 days later. His past medical history included hyperlipidemia, arrhythmia, chronic obstructive pulmonary disease, asthma, benign prostatic hypertrophy, bilateral knee surgeries, and lithotripsy. The patient was fully independent with activities of daily living prior to the stroke. The patient lived with his wife in a second floor condominium. At the initial evaluation, right lower extremity strength testing was documented as follows: hip flexion (4+/5), and knee flexion, knee extension, ankle dorsiflexion, and ankle plantarflexion (5/5). Left lower extremity strength testing was documented as follows: hip flexion (3-/5), knee flexion (3+/5), knee extension (3-/5), ankle dorsiflexion (2+/5), and ankle plantarflexion (3+/5). Sensation was intact to light touch bilaterally on both lower extremities. The patient was able to ambulate 100 feet with a rolling walker and with minimal contact assistance from the physical therapist, receiving a Functional Independence Measure (FIM) score of 2 for locomotion on a level surface. The patient required minimal contact assistance for bed mobility and chair transfers, receiving a FIM score of 5 for transfers involving all aspects of transferring from a bed to a chair and back.

*Current Status*

At 1 week, the patient’s right lower extremity strength testing was unchanged. Left lower extremity strength testing was documented as follows: hip flexion (3-/5), knee flexion (2+/5),
knee extension (3-/5), ankle dorsiflexion (2+/5), ankle plantarflexion (3+/5). The patient was able to ambulate 300 feet with a rolling walker and with minimal contact assistance from the physical therapist, receiving a FIM score of 4 for locomotion. The patient required supervision for bed mobility and chair transfers, receiving a FIM score of 5 for transfers.

**Intervention**

Three trials of gait training were performed; first without the use of any dorsiflexion assistance, second while wearing a posterior leaf spring AFO, and a third time while utilizing Ace© wrap bandaging. The patient was fitted for a 2-wheeled rolling walker prior to performing any interventions. Standby supervision was provided to the patient by a physical therapist during each of the trials. The patient was instructed to ambulate 10 meters at his usual pace with the rolling walker, and without the use of other external aids. For the second trial, an Ossur posterior leaf spring for the left foot was inserted into the patient’s shoe. The patient’s foot was placed into the shoe and the strap was secured. The patient was instructed to ambulate 10 meters at his usual pace with the rolling walker while wearing the posterior leaf spring. In the final trial, the patient’s left foot was wrapped into observed neutral dorsiflexion and slight eversion with a 4 inch Ace© elastic bandage starting from the distal foot to the proximal ankle in a figure-8 fashion. The patient was instructed to ambulate 10 meters with the rolling walker at his usual pace while utilizing the Ace© wrap bandaging. The patient was provided with rest breaks ranging from 45 seconds to 1 minute in between trials to allow for fitting of the posterior leaf spring, and during wrapping with the elastic bandaging. The patient ambulated with standby supervision during all three trials of gait training. In addition to requiring an assistive device, the patient required more than a reasonable amount of time to complete the activity in previous physical therapy sessions.
Performance Measures

To assess the patient’s performance during gait, the following objective measures were utilized: gait velocity, cadence, joint positioning at the trunk, the hip, and the knee assessed by the “Coaches Eye” Video Analysis software, and the gait section of the Tinetti Performance Oriented Mobility Assessment. Appendix A includes the Tinetti Performance Oriented Mobility Assessment scoring sheet for gait (Tinetti, 1986). The patient’s gait was analyzed through video recordings with the permission of the patient. The “Coaches Eye Video Analysis” app was used to measure joint angles at the trunk, hip, and knee during gait and to determine the patient’s step length and stride length. Gait velocity and cadence were recorded with a stop watch. Tinetti gait scores were documented during all three trials of gait training. Markers were placed on bony landmarks on the patient to allow for easy identification during gait and to measure joint angles. Pieces of athletic tape were placed at the acromial angle bilaterally, C7/T1 junction, T12/L1 junction, posterior superior iliac spine bilaterally, lateral epicondyle of the femur on the left lower extremity, and the lateral malleolus on the left lower extremity.

Outcomes

Without any dorsiflexion assistance, the patient ambulated at 0.588 m/s, with a cadence of 67 steps per minute. The patient received a Tinetti gait score of 9 out of 12. With the posterior leaf spring AFO, the patient ambulated 0.555 m/s, with a cadence of 67 steps per minute. The patient received a Tinetti gait score of 7 out of 12. With the Ace© wrap, the patient ambulated 0.8333 m/s, with a cadence of 80 steps per minute. The patient received a Tinetti gait score of 9 out of 12. The patient demonstrated a 2 point increase in the Tinetti gait score, a 29.4% increase in gait velocity, and a 16% increase in cadence while utilizing the Ace© wrap bandaging when compared to results without any dorsiflexion assistance. With the posterior leaf spring, the patient demonstrated a 2 point decrease in the Tinetti gait score, a .06% decrease in gait velocity,
and no change in cadence when compared to results without any dorsiflexion assistance. Changes in joint positioning were noted throughout the gait cycle when the patient wore the posterior leaf spring. The results obtained while utilizing the posterior leaf spring were compared to measures obtained without any dorsiflexion assistance. At initial contact, the patient demonstrated decreased hip flexion and knee flexion, by 4° and 6° respectively. During the loading response, the patient demonstrated a 14° decrease in hip flexion and a 5° decrease in knee flexion. At midstance, no appreciable differences in hip and knee positioning were noted. During terminal stance, the patient demonstrated decreased hip and knee flexion, by 8° and 6° respectively. At preswing, an 8° increase in hip flexion and a 15° increase in knee flexion were noted. During initial swing, the patient demonstrated a 5° increase in hip flexion and no appreciable difference in knee positioning. At midswing, the patient demonstrated a 12° decrease in hip flexion and an 11° increase in knee flexion. Finally, at terminal swing, the patient demonstrated a 3° increase in hip flexion, and no appreciable difference in knee positioning.

Changes in joint positioning were also noted throughout the gait cycle when the patient utilized the Ace© wrap bandaging. The results obtained with the Ace© wrap bandaging, were compared to results without any dorsiflexion assistance. At initial contact, the patient demonstrated a 9° decrease in hip flexion and no appreciable difference in knee positioning. During the loading response, the patient demonstrated decreased hip and knee flexion, by 15° and 13° respectively. At midstance, the patient demonstrated no appreciable difference in hip positioning, but a 3° increase in knee flexion was noted. During terminal stance, no appreciable differences were noted in either hip or knee positioning. At preswing, no appreciable difference was noted in hip positioning, but a 4° decrease in knee flexion was noted. During initial swing, the patient demonstrated no appreciable difference in hip positioning and a 6° decrease in knee flexion. At
midswing, the patient demonstrated decreased hip and knee flexion, by 24° and 9° respectively. Finally, at terminal swing, the patient demonstrated no appreciable difference in hip positioning and a 3° increase in knee flexion. The results of the joint angles at the hip and knee during gait are shown below in Table 3 and Table 4.

Table 1: Gait speed and cadence

<table>
<thead>
<tr>
<th>10 meter walk</th>
<th>Gait speed (m/s)</th>
<th>Cadence (steps per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No assistance</td>
<td>0.588</td>
<td>67</td>
</tr>
<tr>
<td>AFO</td>
<td>0.555</td>
<td>67</td>
</tr>
<tr>
<td>Elastic wrap</td>
<td>0.833</td>
<td>80</td>
</tr>
</tbody>
</table>

Table 2: Tinetti gait assessment

<table>
<thead>
<tr>
<th>Tinetti gait assessment</th>
<th>No assistance</th>
<th>AFO</th>
<th>Elastic wrap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation of Gait</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Step Length and Height</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Foot clearance</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Step Symmetry</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>Step Continuity</td>
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</tr>
<tr>
<td>Path</td>
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<td>Trunk</td>
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<td>0</td>
</tr>
<tr>
<td>Walking Stance</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Gait score</strong></td>
<td><strong>9/12</strong></td>
<td><strong>7/12</strong></td>
<td><strong>9/12</strong></td>
</tr>
</tbody>
</table>

Table 3: Joint angle measurements during stance phase of gait

<table>
<thead>
<tr>
<th>Joint angles</th>
<th>Initial Contact</th>
<th>Loading Response</th>
<th>Mid Stance</th>
<th>Terminal Stance</th>
<th>Pre Swing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No assistance</td>
<td>Hip 38° flexion</td>
<td>35° flexion</td>
<td>20° flexion</td>
<td>15° flexion</td>
<td>11° flexion</td>
</tr>
<tr>
<td></td>
<td>Knee 14° flexion</td>
<td>20° flexion</td>
<td>11° flexion</td>
<td>17° flexion</td>
<td>32° flexion</td>
</tr>
<tr>
<td>AFO</td>
<td>Hip 32° flexion</td>
<td>21° flexion</td>
<td>21° flexion</td>
<td>7° flexion</td>
<td>19° flexion</td>
</tr>
<tr>
<td></td>
<td>Knee 8° flexion</td>
<td>15° flexion</td>
<td>13° flexion</td>
<td>11° flexion</td>
<td>47° flexion</td>
</tr>
<tr>
<td>Elastic wrap</td>
<td>Hip 29° flexion</td>
<td>20° flexion</td>
<td>21° flexion</td>
<td>4° flexion</td>
<td>9° flexion</td>
</tr>
<tr>
<td></td>
<td>Knee 13° flexion</td>
<td>7° flexion</td>
<td>12° flexion</td>
<td>18° flexion</td>
<td>38° flexion</td>
</tr>
</tbody>
</table>
Table 4: Joint angle measurements during swing phase of gait

<table>
<thead>
<tr>
<th>Joint angles</th>
<th>Initial Swing</th>
<th>Mid Swing</th>
<th>Terminal Swing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No assistance</td>
<td>Hip 15° flexion</td>
<td>44° flexion</td>
<td>32° flexion</td>
</tr>
<tr>
<td></td>
<td>Knee 53° flexion</td>
<td>25° flexion</td>
<td>8° flexion</td>
</tr>
<tr>
<td>AFO</td>
<td>Hip 20° flexion</td>
<td>32° flexion</td>
<td>35° flexion</td>
</tr>
<tr>
<td></td>
<td>Knee 52° flexion</td>
<td>36° flexion</td>
<td>9° flexion</td>
</tr>
<tr>
<td>Ace© wrap</td>
<td>Hip 16° flexion</td>
<td>20° flexion</td>
<td>33° flexion</td>
</tr>
<tr>
<td></td>
<td>Knee 47° flexion</td>
<td>16° flexion</td>
<td>11° flexion</td>
</tr>
</tbody>
</table>

Discussion

Regardless of the type of dorsiflexion assistance, the patient demonstrated observed excessive trunk flexion throughout the gait cycle. This may have been exacerbated by the use of a walker. The patient also demonstrated increased hip flexion and knee flexion throughout the gait cycle as well as a lack of hip extension at terminal stance. The patient had one episode of “toe catch” resulting in the inability to clear the left foot completely while wearing the posterior leaf spring. Additionally, a wider base of support could be seen during gait. It appears that both the elastic wrap bandaging and the posterior leaf spring had its greatest influence at initial contact, loading response, terminal stance, and midswing as determined by the differences in change of either hip flexion, knee flexion, or both throughout the gait cycle. When utilizing the elastic wrap bandaging, better joint positioning was noted during gait, leading to a greater difference in joint measurements, when compared to the posterior leaf spring. The use of Ace© wrap bandaging for dorsiflexion resulted in beneficial outcomes for the patient. The increased gait speed and cadence may indicate decreased energy expenditure and increased efficiency during ambulation. It is also possible that this increase may be attributed to the increased practice of gait after multiple trials. No differences were seen in the Tinetti gait assessment scores between the initial trial, without any dorsiflexion assistance, and the final trial, utilizing the
Ace© wrap. Although it appears that the Ace© wrap bandaging had no significant effect on the parameters assessed in the Tinetti POMA, it should not dissuade therapists from using it as an intervention in the clinic. Although the Tinetti is widely used in the clinic due to the reliability and validity of the tool in this population, the cost and ease of its administration, and the time it takes to administer, it was not the most optimal outcome measure to use for this study. The Tinetti POMA is a general performance test that is not specific in assessing the quality of movement, rather it identifies the presence or absence of a deviation through a 2 point or a 3 point ordinal scale. It is unable to accommodate for large variability in data. Thus, for higher functioning adults, like the case patient, the Tinetti POMA was not an ideal outcome measure to use because of the likely ceiling effects of the ordinal scales used in the tool. Other gait measures should be considered, such as the Wisconsin Gait Scale or the Functional Gait Assessment to assess gait characteristics in patients with hemiplegia following stroke. Additionally, the correlation between the posterior leaf spring and the decreased Tinetti scores was unexpected. A review of the literature revealed improvements in velocity, symmetry, and foot clearance during swing while utilizing a plastic AFO in the neurologic population, none of which occurred in this case study. Due to the fact that the posterior leaf spring is not a custom orthotic, sizing issues such as being too large or too small for the patient, may alter or impair sensory awareness in the foot, leading to inaccurate proprioceptive input during gait. Additionally, maintaining an ankle in a neutral position throughout the gait cycle is not optimal; the ankle requires a certain amount of dorsiflexion and plantarflexion throughout the gait cycle to create a normal gait pattern. Furthermore, the presented case patient was higher level based on his FIM scores, his level of independence with gait, and his lower extremity MMT grades, thus the posterior leaf spring may have diminished his ability to walk well. Results of this study may differ with a patient who
presents with greater impairments. It is well known that higher repetitions at greater intensities are associated with neuroplastic changes needed for motor recovery. The results obtained from this study demonstrate that elastic wrap bandaging for dorsiflexion assistance facilitates better joint positioning at the ankle, and increases cadence and gait speed in a patient with subacute stroke, all of which have the potential to enhance motor recovery. Given the clinical benefits of elastic wrap bandaging, clinicians should be confident in utilizing this technique during ambulation activities in this population to assist in motor recovery. Some limitations to this case report were identified. First, intra-rater reliability for joint angle measurements using Coach’s eye has not been studied. Therefore, it is difficult to determine the accuracy of the obtained measurements. Additionally, the use of the posterior leaf spring may not be a true representation of the patient’s ability to ambulate. Since the AFO was prefabricated, it may not have been an ideal fit for the patient, thus impairing his ability to control the ankle during gait. It does not appear that fatigue had an influence on the patient’s gait kinematics. The patient had equal rest breaks between trials and had the best outcomes while utilizing the elastic wrap at the last trial.

**Conclusion**

Ace© wrap bandaging was a feasible, and a better alternative than the use of a non-custom posterior leaf spring in this patient with subacute stroke. The patient demonstrated a trend toward greater gains in mobility and motor control while utilizing the elastic wrap during ambulation. There were no clinical benefits of using a posterior leaf spring in the management of foot drop during gait training, and in fact was disadvantageous to the patient. The patient demonstrated the best performance during ambulation with the Ace© wrap bandaging, followed by without any dorsiflexion assistance, and the least favorable performance with the posterior leaf spring. Although Ace© wrap bandaging allows the ankle to be passive, the elasticity from it
may be providing proprioceptive feedback to the patient, thus encouraging motor control at the ankle. This case report suggests that the use of Ace© wrap bandaging as an adjunct intervention may be beneficial in the early management of foot drop in patients with subacute stroke. Further studies should focus on a larger sample size to confirm the effectiveness of elastic wrap bandaging as a treatment intervention for foot drop. Additionally, the use of motion capture systems, such as the Qualisys, may be a superior option for determining joint angles due to the motion sensor detectors. Lastly, other assessment scales should be used and other wrapping techniques should be utilized to assess the influence of Ace© wrap bandaging on other important aspects of gait, such as stair negotiation and pivot turns.
References:


Appendix A:

Tinetti Performance Oriented Mobility Assessment (POMA)

Initial Instructions: Subject stands with examiner, walks down hallway or across room, first at “usual” pace, then back at “rapid, but safe” pace (using usual walking aids)

**Initiation of Gait** (immediately after told to “go”)

| Any hesitancy or multiple attempts to start | 0 |
| No hesitancy                              | 1 |

**Step Length and Height**

Right swing foot

| Does not pass left stance foot with step | 0 |
| Passes left stance foot                 | 1 |
| Right foot does not clear floor completely |
| With step                                | 0 |
| Right foot completely clears floor       | 1 |

Left swing foot

| Does not pass right stance foot with step | 0 |
| Passes right stance foot                 | 1 |
| Left foot does not clear floor completely |
| With step                                | 0 |
| Left foot completely clears floor         | 1 |

**Step Symmetry**

| Right and left step length not equal (estimate) | 0 |
| Right and left step length appear equal       | 1 |

**Step Continuity**

| Stopping or discontinuity between steps       | 0 |
| Steps appear continuous                       | 1 |
**Path** (estimated in relation to floor tiles, 12-inch diameter; 
Observe excursion of 1 foot over about 10 ft. of the course)

- Marked deviation = 0
- Mild/moderate deviation or uses walking aid = 1
- Straight without walking aid = 2

**Trunk**

- Marked sway or uses walking aid = 0
- No sway but flexion of knees or back or 
  Spreads arms out while walking = 1
- No sway, no flexion, no use of arms, and no 
  Use of walking aid = 2

**Walking Stance**

- Heels apart = 0
- Heels almost touching while walking = 1

\[
\text{GAIT SCORE} = \underline{\text{_____}}/12
\]
\[
\text{BALANCE SCORE} = \underline{\text{_____}}/16
\]
\[
\text{TOTAL SCORE (Gait + Balance)} = \underline{\text{_____}}/28
\]

{< 19 high fall risk, 19-24 medium fall risk, 25-28 low fall risk}

(Tinneti, 1986)