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## RESEARCH ABOUT USING DROP FOOT ORTHOSES FOR GAIT REHABILITATION IN PATIENTS WITH DORSIFLEXION DEFICIT

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### Abstract

**Aim.** In gait recovery, AFO orthoses are prescribed to normalize the gait pattern in people with foot dorsiflexion disorders. There are several types of AFO orthoses, but stiffness and discomfort characterize a large proportion of them. The main aim of the study is to find the most suitable ankle-foot orthosis for inclusion in our rehabilitation program. The most important research objective of the present work is to improve the gait of people with dorsiflexion deficiency of the foot.

**Methods.** The current standard of conventional treatment for dorsiflexion deficiency involves the use of an ankle-foot orthosis to maintain the joint during gait. The study was conducted over a period of 4 months, from December 2023 to March 2024 and consisted in the selection of a target group of 42 people with foot dorsiflexion control deficit who used the AFO orthosis according to the indications of gait recovery specialists. For this study we chose the experiment method in which we will compare the advantages or disadvantages of using an ankle-foot orthosis for gait improvement and the test method in which we will objectively present whether there are improvements in gait parameters compared to a group not wearing an ankle-foot orthosis. As an assessment item we will use the Timed Up and Go Test (TUG), a test used to assess balance and risk of falls.

**Results.** As for the results of the Timed Up and Go test we observed that all participants obtained times that fall within the range of a gait with balance problems and high fall risk. Although they used the ankle-foot orthoses, the times obtained did not decrease significantly, remaining within the same range of test interpretation, somewhat anticipated aspect being the first time participants used an ankle-foot orthosis for this purpose.

**Conclusions.** Ankle and foot orthoses are essential for improving the quality of life of patients with various musculoskeletal and neurological conditions. They provide support, stability, correctly align limbs, relieve pain and contribute to faster and more efficient recovery. Their customization and adaptability make them a valuable tool in the therapeutic arsenal for a wide range of conditions.

**Keywords:** Drop foot, orthoses, gait rehabilitation.

### Introduction

The comprehensive approach to stroke rehabilitation requires not only clinical but also functional assessment. The assessment steps address a large number of methods that allow to build predictions about the course of functional rehabilitation. To this end, a biomechanical assessment can help to identify morpho-functional changes in the foot, starting with the assessment of plantar pressure and including the assessment of the foot contact area.

When there are morphofunctional disorders in the foot, changes in plantar pressure, changes in the center of pressure and changes in the contact area of the foot occur (Caliskan Uckun et al., 2014). These manifestations can describe the characteristics of the foot of stroke patients. At the same time, kinetic changes occur after stroke and in this context the measurement of plantar pressure and other gait parameters become a challenge for physical therapy intervention.

Spasticity of plantar flexor muscles generates foot drop, and the center of pressure of the foot has an anterior motion influencing the activity of plantar flexor muscles and thus increases foot inversion (Yamada, Ohta & Tamari, 2022), (Wang et al., 2023). The connection between morpho-functional changes of the foot and the evolution of the center of pressure of the foot in different pathological states have been studied by several authors who have reported functional changes of the foot axis and subtalar joint angle (McCann et al., 2021), (Houston et al., 2015), (McCann et al., 2018). Starting from these findings we aimed to identify the optimal gait recovery strategy taking into account the morphofunctional changes occurring in the foot in the compensatory gait strategy after stroke.

### Objectives

Starting from the importance of the morpho-functional changes that occur in the foot after a stroke and their impact on the gait recovery plan, we aimed to identify the most appropriate gait recovery strategy by using combined methods

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of kinesiotherapy and modern orthotics. Therefore, we set out to conduct a study on the use of ankle-foot orthoses in people with dorsiflexion deficit. The main aim of the study is to find the most suitable ankle-foot orthosis for inclusion in our rehabilitation program. The most important research objective of the present work is to improve the gait of people with dorsiflexion deficiency of the foot. The current standard of conventional treatment for dorsiflexion deficiency involves the use of an ankle-foot orthosis to maintain the joint during gait (Kottink et.al., 2004).

We believe that ankle and foot joint orthotics is a key element in achieving the proposed therapeutic goals. In order to include an ankle-foot orthosis in the therapeutic plan, we conducted a longitudinal study to identify the best orthosis solution. For the research, we chose a Romanian company that deals with the production and distribution of medical devices, a company that is currently the absolute leader on the medical devices market in Romania.

#### *Orthoses concept*

Orthoses are external medical devices that are used therapeutically to align, support, correct or prevent dysfunctions or deformities of the musculoskeletal system due to various causes. They can be used to stabilize a body segment or joint, improve physical function, reduce pain or prevent further damage to an affected structure (An et.al., 2024). Orthotics is often an essential component of the treatment plan for various musculoskeletal conditions, providing essential support and stability for recovery and improved quality of life.

The main purpose of orthotics is the functional restoration of the myoarthrokinetic apparatus with minimal restriction of physical activity (Cinteza & Poenaru, 2004). Depending on the purpose for which they are used, they determine a series of advantages in the recovery process, such as:

- joint stabilization and support;
- reducing pain and discomfort (limiting movement or supporting an affected area);
- preventing and correcting deformities;
- improving functionality;
- reducing the risk of recurrence (preventing recurrence of an injury by providing additional support during activities that may put pressure on vulnerable areas);
- improving posture (by maintaining correct body alignment);

#### *Lower limb orthotics in neurological recovery*

In order to correct various dysfunctions occurring in the foot joint, modern medicine uses various orthotic systems and devices. Gait rehabilitation is a multidisciplinary process that involves significant time and effort, but the use of appropriate medical devices can accelerate the recovery process and significantly improve patients' quality of life (Choo & Chang, 2021). The ankle-foot orthosis is used for gait rehabilitation with dorsiflexion deficiency. The ankle-foot orthosis is an orthosis commonly used in people who have weakness of ankle and foot flexor muscles due to several neurological disorders such as stroke, spinal cord injury, cerebral palsy or peripheral nerve injury (Pourhosseingholi et.al., 2019), (Bregman et.al., 2010). This type of orthosis supports gait by stabilizing and maintaining ankle and foot alignment, corrects and prevents ankle and foot deformities, provides clearance between the foot joint and the ground during the swing phase of gait, and maintains a stable posture by allowing heel contact with the ground during the stance phase (Ploeger et.al., 2014), (Alam et.al., 2014). The – foot ankle orthoses used in neurological gait recovery are called AFO orthoses (the name is the acronym of the AFO English translation – ANKLE-FOOT ORTHOSES). The use of these orthoses offers multiple benefits by improving gait symmetry during swing and stance phases, providing balance and increasing gait speed and cadence (Cinteza et.al., 2011, p. 61).

AFO orthoses are indicated for assisting the functionality of the ankle-foot complex in people with neurological disorders and their fundamental role is to balance the forces acting on the segments in both static and dynamic (Cinteza et.al., 2011, p. 51 - 52). A study published by Kobayashi et al. in 2017 demonstrated the contribution of the use of an ankle-foot orthosis to the regulation of ankle and knee biomechanics in post-stroke individuals. The ankle-foot orthosis maintained the ankle joint at an average dorsiflexion angle and implicitly an average position of knee flexion motion during a gait cycle. Wearing the orthosis showed a more defined moment of dorsiflexion of the foot and an improvement in heel-to-ground contact (Kobayashi et.al., 2017), (Braddom, 2015, p. 357).

Ankle - Foot Orthoses are medical devices that play a crucial role in the management and treatment of various conditions that affect ankle and foot mobility and functionality. Their importance can be detailed on several levels:

- stabilization and support (ankle and foot orthoses provide additional stabilization and support to the ankle joint, reducing the risk of sprains and other injuries. They are essential for people with chronic ankle instability, either due to ligament damage or neurological conditions)
- correction and alignment (orthotics can correct and align the position of the ankle and foot, helping to prevent and treat deformities such as flat foot (flatfoot) or cavus foot (plantar arch too high). They help distribute weight correctly over the surface of the foot and improve overall biomechanical alignment)
- pain relief (by providing stabilization and support, ankle and foot orthoses can reduce the pain associated with various conditions and help reduce inflammation and prevent overloading of specific areas of the foot)

- improve functionality and mobility (orthotics allow safer and more efficient movement, allowing patients to move around with less fatigue and discomfort. They are useful in post-operative recovery, as well as in the management of neurological conditions affecting muscle control and coordination, such as cerebral palsy or stroke);
- prevent further damage (by providing adequate support, ankle and foot orthoses can prevent further damage to the affected structures and reduce the risk of injury recurrence. This is particularly important for athletes and physically active people);
- adaptability and customization (modern orthotics can be tailored to suit the specific needs of each patient, providing optimal support and comfort. Materials and design can vary to suit different activities and activity levels)

### Methods

The level of movement after an injury such as stroke is a long-term predictor of disability. Reducing motor control in the lower extremities impairs overall mobility and decreases quality of life. In gait recovery, AFO orthoses are prescribed to normalize the gait pattern in people with foot dorsiflexion disorders.

The study was conducted over a period of 4 months, from December 2023 to March 2024 and consisted in the selection of a target group of 42 people with foot dorsiflexion control deficit who used the AFO orthosis according to the indications of gait recovery specialists.

Of the total of 42 people, 29 belong to the urban environment and 13 belong to the rural area. The average age of the study group was 43.25 years, the minimum age was 40 years and the maximum age was 50 years and in terms of gender, 31 persons were male and 11 female.

The patients included in the study were diagnosed with ischemic stroke, gait disturbance with impaired dorsiflexion control of the foot with the possibility of autonomous or supported ambulation.

For the experimental part we used a textile orthosis that supports the flexion movement of the foot. It has various accessories, it can be used with or without footwear with the help of a plantar band that provides comfort, compression and stability and is part of the accessories. It consists of a supramalleolar band with a silicone cushion for added comfort, an accessory that secures the orthotic to the footwear and an adjustable elastic band that supports the flexion movement and ensures the foot is lifted off the ground (Figure 1).



Figure 1. Prim Textile Drop Foot Orthotic (<https://ortoprofil.ro>)

For this study we chose the experiment method in which we will compare the advantages or disadvantages of using an ankle-foot orthosis for gait improvement and the test method in which we will objectively present whether there are improvements in gait parameters compared to a group not wearing an ankle-foot orthosis.

As an assessment item we will use the Timed Up and Go Test (TUG), a test used to assess balance and risk of falls. This test consists of a four-stroke circuit that the subject will go through and will be timed, a time as small as possible representing the best walking ability.

To perform the test, the subject must be seated in a chair with a recommended sitting height of 45-47 cm. On the command "start" the subject has to get up from the chair (time 1) walk three meters (time 2), go around a milestone (time 3) and return to the chair (time 4), the same distance of three meters (Figure 2). The timer starts on the command "start" and stops when the subject has sat back down on the chair (Ortega-Bastidas et.al., 2023).

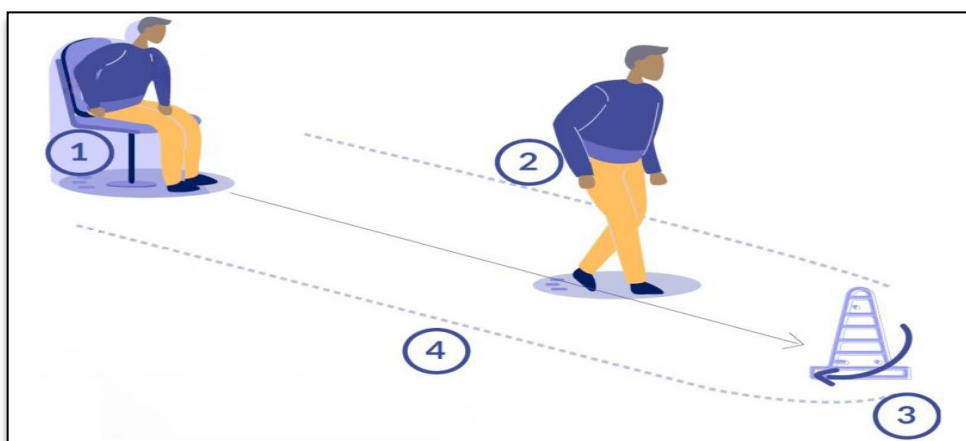


Figure 2. Test presentation "Test Timed Up and Go" (Ortega-Bastidas et.al., 2023)

The controlled variable of the Timed Up and Go test is given by the total duration of the circuit expressed in seconds. This test shows high intra-assessment and inter-assessment reliability and shows higher values in people with Parkinson's disease or stroke and is recommended for measuring basic mobility skills after stroke in patients who are able to walk (Hafsteinsdóttir et.al., 2014). Test interpretation is simple. It is considered that a time equal to or less than 10 seconds is a normal walk, a time between 11 and 20 seconds is a relatively good mobility, specific to a disabled person and a time greater than 20 seconds indicates that the person requires walking assistance (Ortega-Bastidas et.al., 2023). The results obtained correlate with the functional level, balance, speed of walking and the ability of the subject to quickly adapt to changes in direction.

### Results

As for the results of the Timed Up and Go test (Figure 3) which assesses dynamic balance and fall risk, we observed that all participants obtained times that fall within the range of a gait with balance problems and high fall risk. Although they used the ankle-foot orthoses, the times obtained did not decrease significantly, remaining within the same range of test interpretation, somewhat anticipated aspect being the first time participants used an ankle-foot orthosis for this purpose.

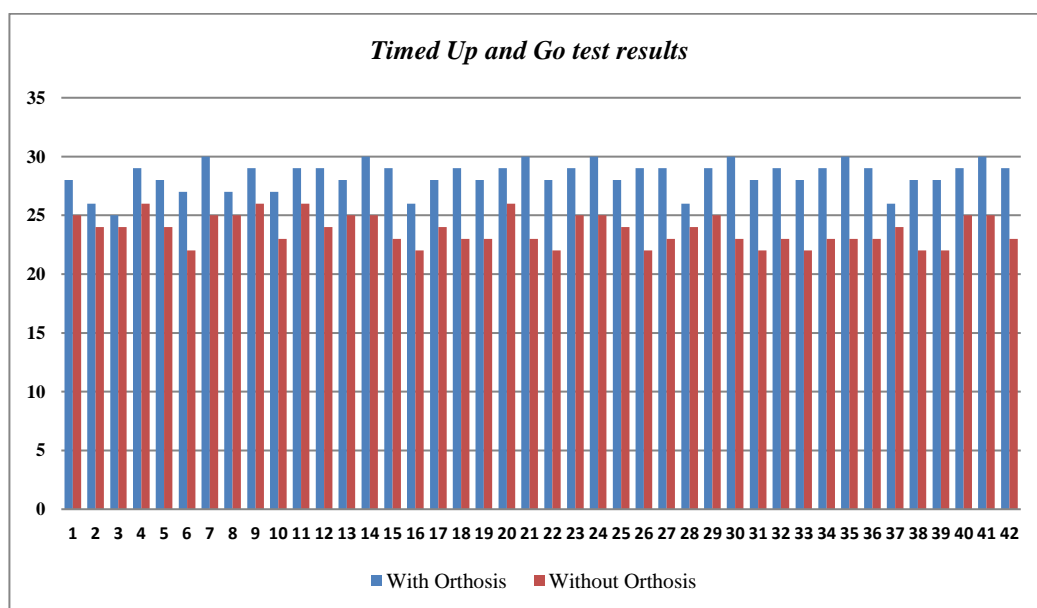


Figure 3. Presentation of test results "Test Timed Up and Go"

Although the times achieved while wearing orthoses are not significantly better than walking without orthoses, there is still an improvement to consider when reasoning the choice of using orthoses in a gait rehabilitation program. In Table 1. we present the progress achieved by participants wearing orthoses, the value compared to walking free.

Table 1. Progress on the Timed Up and Go test by wearing orthoses

	<i>Walking free, no orthosis</i>	<i>Walking with orthosis</i>
<i>Score</i>	28,38 s	23,74 s
<i>Progress</i>	-	16,35 %

### Discussions and conclusions

People with stroke develop abnormal gait patterns as a compensating means due to loss of balance ability and acquired muscle weakness. They experience a decrease in walking capacity due to the inability to move symmetrically the weight and have an asymmetric stride length developed as a result of the weakened acceleration force of the paralyzed extremities. Moreover, the lower extremities with motor impairments result in limitation of the movements of the upper extremities and an increase in asymmetric gait (Tahmasbi et al., 2023).

Wearing the orthosis showed a more defined moment of foot dorsiflexion and an improvement in the contact of the heel with the ground that were manifested by a higher walking speed.

By addressing the strategy of using the – foot ankle orthosis in the walking recovery stage we have the following expectations:

- supporting the alignment of the ankle-knee complex;
- reducing ankle instability;
- correct tilting of the pelvis during gait;
- facilitating the detachment of the foot from the support surface in the pre-balance phase;
- influencing energy consumption;
- improving heel strike;
- improving the detachment of the foot from the ground in the swing phase of walking;
- Increasing gait speed;
- preventing inversion injuries;

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