Utility and effectiveness of ankle-foot orthoses in individuals with hemiparesis: a literature review on cerebral palsy and stroke

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Abstract

Background: Ankle-foot-orthoses (AFOs) are used on the lower limb in people with hemiplegia. They prevent deterioration and improve walking ability by limiting abnormal and unneeded movements.

Aims: The purpose of this study was to present the possibilities and attempt to evaluate the effectiveness of the use of AFO orthoses in patients with hemiparesis based on examples of cerebral palsy and stroke. In addition, to present the competence and authority of the master's and physiotherapy specialist to order orthopedic supplies for the lower limb.

Material and methods: The available literature was analyzed based on English-language databases PubMed, Scopus, ScienceDirect, Medline and others, using the Google Scholar search engine. There were 21 articles analyzed out of 70 retrieved by the above method. Publications no older than 14 years were used as search criteria using the following keywords: AFO, stroke, cerebral palsy, orthosis, orthopedic supplies, hemiparesis, medical device ordering.

Results: Contemporary studies indicate that properly selected and used AFO orthoses improve gait parameters and foot alignment. The use of different types of AFOs can affect outcomes. Custom-made AFOs can be ordered by a physiotherapy specialist, serial ones by master of physiotherapy.

Conclusions: the use of AFO orthoses can effectively support the rehabilitation process in people with hemiparesis.

Key words

stroke, cerebral palsy, AFO, orthosis, orthopedic supplies, hemiparesis, medical device order.

Introduction

Numerous disease entities such as cerebral palsy and stroke lead to the foot impairment. Dysfunction in the ankle joint contributes to an increased risk of falls due to an unbalanced gait. The best way to eliminate falls is to invent a tool to correct the impairment occurring in the lower limb area [1].

Nowadays, orthoses are becoming an increasingly integral part of a comprehensive physiotherapeutic plan less often associated with immobilization and blocking movement. Three main aspects of the use of orthopedic supplies can be mentioned in the broad treatment process: correction, function, comfort. Each of these three features is important and the order relative to each other should determine the situation in which the use of orthoses was initiated [2].

The ankle-foot-orthosis (AFO) covers the foot, ankle joint, and lower leg. Its purpose is to correct the structure of the skeletal and neuromuscular systems. Depending on the need for stabilization and the degree of deformity, orthoses can be of various types [3]. It is important to choose the design of the AFO accordingly and consider its specific impact on patients with foot impairments. It has been proven that different variants of AFOs exhibit distinct mechanical properties, which can influence the outcomes.

AFO prevents deterioration and improves walking ability by reducing abnormal and unnecessary movements. Additionally, it maintains stability and enhances the ability to bear weight on the lower extremities. When walking with an AFO, patients experience greater stability, safety, and less fatigue than when walking with shoes alone. However, AFOs also have some disadvantages. First, to some extent, they can limit lower limb muscle activity after an extended period, and second, certain types of orthoses are bulky and heavy due to the materials and components mounted on them [1].

Originally, AFOs were manufactured from hard and brittle materials that were prone to damage, lacking adequate flexibility [4]. Currently, with the advancements in biomechanics, AFO materials and components have significantly improved, giving rise to multifunctional, custom-fitted AFOs. These modern AFOs are crafted from materials such as polypropylene, polyethylene, carbon fiber, and their composites [5-7].

The Law on the Profession of Physiotherapist, dated September 25, 2015 (Journal of Laws of 2018, item 505), as amended by the Speaker of the Parliament of the Republic of Poland on April 12, 2019, regulates the physiotherapist profession, now recognized as an independent medical profession. The law outlines the scope of health services that a physiotherapist can offer, with three of the ten rules directly and one indirectly addressing medical devices and their use in physiotherapy treatment.

The Minister of Health's Regulation on the list of medical devices permits master and specialist physiotherapists to prescribe reimbursable medical devices. This applies to both commercial practices registered with the National Health Service and those with a contract with the National Health Service. The authority to issue such orders is granted individually to each authorized physiotherapist.

The Law on the Profession of Physiotherapist mandates that physiotherapists possess the skills, knowledge, and social competence necessary to appropriately select prosthetics and musculoskeletal orthotics [8,9].

Aims

The purpose of this study was to demonstrate the applicability of AFO-type orthoses and attempt to evaluate their effectiveness in patients with hemiparesis, using cerebral palsy and stroke as examples. Additionally, the study aimed to highlight the competence of the physiotherapist in prescribing orthotic supplies for the lower limb.

Material and methods

The available literature was analyzed using English-language databases such as PubMed, Scopus, ScienceDirect, Medline, and others, with the assistance of the Google Scholar search engine. Out of the 70 articles retrieved through this method, 21 were selected for analysis. Publications no older than 14 years were considered, employing the following keywords: AFO, stroke, cerebral palsy, orthosis, orthopedic supplies, hemiparesis, and medical device ordering.

Results

After reviewing the papers, no clear answer could be found to determine which AFO orthosis is the most effective. AFO orthoses primarily enhance gait speed, stride length, and rhythm in patients with hemiparesis. The market offers numerous types of orthoses, which should be selected by a physiotherapist based on the degree of foot correction and utilized in the rehabilitation process. AFOs can be ordered by individuals with a master's degree and by physiotherapy specialists. A master's degree holder in physiotherapy, upon achieving independent professional status, is authorized to order serial orthopedic supplies. Furthermore, a master's degree holder who has undergone specialty training can prescribe individually customized orthopedic supplies. **Tables 1-3** below present the various types of orthoses used for individuals with hemiparesis and provide information on the prescription of medical supplies by physiotherapists.

Table 1. Types of gait in spastic diplegia in cerebral palsy, including recommended orthoses – original content based on the literature [3,10,11].

Type of gait	Description	Problem	Recommended type of orthosis
Type I	Lack of abnormalities in the support phase, but inadequate ankle extension during pronation.	Onset of tibial muscle failure with possible contracture of the gastrocnemius muscle.	Posterior leaf spring AFO (PLS)
Type II	Overpronation occurs at the knee joint which leads to an abnormal stance phase. Foot all on the ground.	Knee joint hyperextension caused by premature engagement of the triceps surae muscle.	Soft forefoot AFO
Type III	By overpronating the knee joint and positioning the foot in sole flexion, there are abnormalities in the stance phase. Foot positioned in plantar flexion.	Abnormal functioning of the triceps surae muscle and increased activity of the vastus lateralis muscle.	Hinged AFO – adjustable (hAFO)
Type IV	In the stance phase, there are abnormalities of hip and knee flexion, the foot is positioned in plantar flexion.	Incorrect activity with possible contracture of the triceps surae muscle and also the hamstrings muscle group along with the iliopsoas muscle.	Solid AFO with locked forefoot motion
Type V	There is what is known as Crouch, which is the positioning of the hip and knee joint in flexion with the foot in dorsiflexion, flat on the ground.	It can lead to loss of gait ability in adolescence.	Ground reaction AFO (GRAFO)

Table 2. Types of orthoses used in children with spastic form of cerebral palsy, description and function in gait- own material based on the literature [3,12].

AFO name	Description	Effect of orthoses on gait of children with spastic form of CP	Photography
Dynamic AFO (DAFO)	Covering only the ankle joint, this orthosis gives full mobility to the upper ankle joint. Stabilizes the joints of the tarsus and foot.	Used in patients with true equinus: • Increases flexion and extension at the ankle joint during the stance phase • Enables push-off during pre-swing phase • Increases the energy cost of gait	
Solid AFO (sAFO)	Used to block the mobility of the ankle joint and limit the extension and plantar flexion. Additionally, keeping the ankle joint in a neutral position.	In patients with diplegia: • Increases stride length, increases gait speed • Reduces the force of ankle joint excursion in the final stance phase • Reduces the energy cost of gait • Corrects the alignment of the knee joint in the stance and swing phases	
Posterior leaf spring AFO (PLS)	Ankle and foot orthosis with carbon fiber in the shin bone area.	In patients with hemiplegia: • Increases the flexion moment in the knee joint, thus improving gait speed • Enhances push-off in gait • Reduces the energy cost of gait • Improves ranges of motion in the ankle and knee joints	

Table 3. Types of orthoses used in children with spastic form of cerebral palsy, description and function in gait- own material based on the literature [3,10].

AFO name	Description	Effect of orthoses on gait of children with spastic form of CP	Photography
Hinged AFO (HAFO)	It blocks the sole flexion of the ankle joint, allowing the joint to be straightened. Covers the foot and shin.	In patients with hemiplegia: • Increases stride length, increases speed • Increases explosive power during pre-swing gait phase • Reduces the energy cost of gait • Improvement in gait symmetry and one limb stand • Improves the ranges of motion in the ankle and knee joints during the stance and swing phases • Provides an opportunity to develop mobility capabilities	

Ground reaction AFO (GRAFO) Floor reaction orthoses (FRO)	It uses reaction forces from the ground. The orthosis covers the shin in the calf area along with the upper part of the shin and foot. Prevents plantar and dorsiflexion of the ankle, keeping the ankle joint in a neutral position.	In patients with a form of diplegia: • Increases stride length, increases the frequency of steps, increases gait speed • Supports knee joint extension only in patients who do not have knee joint contractures > 15°	

For post-stroke patients, articulated AFO orthoses with adjustable resistance in plantar and dorsal flexion are used [1].

Competence of physiotherapists in ordering orthopedic supplies

Physiotherapists with a master's degree in physiotherapy who have professional autonomy have been granted the right to order serial medical devices defined in the appendix of the regulation as:

- Group J, ordinal no. 36-44
- Group L, ordinal no. 47-53
- Group M, ordinal no. 57-63
- Group O, ordinal no. 69 and 70.

Physiotherapists who hold the title of specialist have additionally been authorized to order medical devices from groups of:

- Group A, ordinal no. 1-3
- Group B, ordinal no. 4-11
- Group C, ordinal no. 12-17
- Group D, ordinal no. 8-20
- Group E, ordinal no. 21
- Group F, ordinal no. 22 and 23
- Group G, ordinal no. 24-27
- Group H, ordinal no. 28-33
- Group I, ordinal no. 34, 35
- Group K, ordinal no. 45, 46
- Group Ł, ordinal no. 54-56
- Group N, ordinal no. 64-68
- Group O, ordinal no. 69 and 70
- Group P, ordinal no. 92 and 93 and 124-133.

With regard to the article in Group J, no. 36-44 there are:

- Ankle joint stabilizing orthosis
- Rigid or semi-rigid plastic orthosis for the shin and foot
- Knee joint orthosis with mobile knee joint and flexion angle adjustment
- Knee joint orthosis covering the entire shin and thigh, with adjustable range of motion,
- Unilateral or bilateral hip immobilization or stabilization orthosis with adjustable angle of flexion or abduction
- Saint-Germain type brace
- Dennis-Brown boot and bar brace
- Orthosis for the entire lower limb with foot capture with adjustable flexion angle at the knee joint
- Inversion orthosis for the treatment of developmental hip dysplasia.

Group H, no. 28-33:

- Orthosis covering the shin and foot or with a stirrup (type AFO)
- Orthosis briefly correcting axial abnormalities in the frontal plane (DAFO or GRAFO type)
- Orthosis covering the thigh, shin and foot (KAFO type)
- Orthosis including hip rim, thigh, shin and foot (HKAFO type)
- Orthosis that relieves load on the lower limb
- Reciprocal orthosis with the possibility of movement in the ankle and knee joints [8,9].

The knowledge necessary to order orthopedic supplies is acquired during specialty training in physiotherapy, while the qualifications for a master's degree in physiotherapy are derived from the course of study pursued during university.

Discussion

A literature review by Aboutorabi et al. [12] on the effectiveness of using different types of AFOs in children with cerebral palsy concluded that the utilization of specific orthotic types improved gait parameters, including stride length, gait speed, and range of motion of the ankle and knee joints. AFOs were found to reduce energy expenditure in children with the spastic form of cerebral palsy. For more reliable results, further studies with good PEDro results are necessary; only then will conclusively evidence regarding the effectiveness of AFOs be available.

In a study by Majewska et al. [13], the use of AFOs in children with cerebral palsy improved temporal-spatial and kinematic gait parameters. The study included 37 children with hemiparesis, and each child underwent instrumented gait analysis in an AFO as well as barefoot during the same clinical gait analysis (CGA) session.

A study by Liu et al. [14] on the long-term effect of orthotic use on changes in foot and ankle mobility in children with spastic cerebral palsy showed that long-term use of AFOs maintains or reduces foot deformities/dysfunctions. This study was conducted over a range of 15-20 months (mean 18 months) on a group of 23 children with cerebral palsy, with a mean age of 10.5 years (6.2-18.1).

Kobayashi et al. [15] conducted a study in which they investigated the mechanical properties and effects of an articulated AFO orthosis with adjustable resistance to sole and dorsiflexion on ankle and knee joint kinematics and kinetics in post-stroke patients. The results indicated that articulated AFO-type orthoses proved to be effective in affecting lower limb joint kinematics and gait kinetics in post-stroke patients. Gait analysis was performed using a 3D motion capture system.

A study by Nikamp et al. [16] investigated the positive effects of AFOs on ankle dorsiflexion at initial contact, terminal stance, and pre-swing. Early or delayed provision of AFOs had no effect on outcomes. In conclusion, a positive short-term effect of AFO provision on ankle joint kinematics in the early post-stroke period was demonstrated.

According to a meta-analysis by Yoo Jin Choo et al. [17], it is evident that AFOs improve gait speed, stride length, and rhythm in post-stroke patients, making them beneficial for enhancing gait stability and walking ability.

Dariabor et al. [18] assumed that the use of AFO-type orthoses can also improve locomotor function in post-stroke patients. However, future studies should explore the long-term effects of rehabilitation with AFOs and compare differences in orthosis designs. No evidence was found regarding the effectiveness of specific AFO designs compared to others.

According to Wada et al. [19], AFOs improved ankle kinematics and walking ability in the short term, but it should be noted that the evidence had a low degree of certainty. The study included fourteen studies involving 282 stroke patients.

Ling et al. [20] studied the impact of AFO types on pelvic and thoracic movements, particularly rotation. Pelvic rotation and lower limb movement showed improvement with AFO-OD (AFO with shock absorber), indicating a more efficient gait quality. However, increased thoracic rotation may manifest as inadequate trunk control and dissociative movements. The study involved 29 post-stroke patients.

In contrast, Yong Feng et al. [1], in a systematic review evaluating 37 full studies on the material and categories of AFOs and their effects on patients with foot impairment, concluded that different types of AFOs have varying effects. AFOs primarily affect gait speed, energy cost of walking, and the stability of standing and walking in patients with foot impairment.

A study by Johnston et al. [21], based on a literature review of 122 meta-analyses, noted that

there is strong evidence supporting the idea that AFOs can enhance gait speed, dynamic balance, and mobility. Moderate evidence suggests improvements in quality of life, muscle activation, and endurance during walking, with weak evidence for improvements in gait kinematics. One limitation of these studies is that they often used different types of AFOs and rarely differentiated their effects. The recommendations also do not account for the severity of hemiparesis, and most of these studies included participants with varying baseline mobility.

Study limitations

The above paper, prepared based on a review of available literature on the use of lower limb orthoses, hemiparesis, and the authority of physiotherapists to order medical supplies, is characterized by the following limitations. It is essential to note that this is not a professional systematic review; the paper does not assess scientific evidence according to evidence-based medicine (EBM) on the described topic and focuses exclusively on the issues of Polish legislation regarding the powers of master's and specialist physiotherapists. Drawing more detailed conclusions requires further research covering the aforementioned issues.

Conclusions

Modern research indicates that properly selected and used AFO orthoses are effective and bring improvements in gait parameters and foot alignment. They predominantly have a positive impact on rhythm, gait speed, and stride length, leading to enhanced gait stability. However, it is worth noting that these studies are mostly short-term, and a longer observation period is necessary for conclusive results. Additionally, it should be noted that various types of AFOs are considered in studies, which can influence the final results. The authority to order medical devices, such as AFO-type orthoses, is held by a specialist and a master's degree in physiotherapy. A physiotherapy specialist can order orthotic supplies made on an individual basis, while a master's degree can order serial supplies. The use of AFO orthoses can effectively support the rehabilitation process in people with hemiparesis.

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