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Review

Effect of different designs of ankle-foot orthoses on gait in patients with stroke: A systematic review

Aliyeh Daryabor[a,b,c], Mokhtar Arazpour[a,b,*], Gholamreza Aminian[b]

[a] Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
[b] Orthotics and Prosthetics Department, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
[c] Student research commute, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

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ABSTRACT

Background: Ankle foot orthoses (AFOs) are used to improve the gait of patients with stroke.
Research question: The current review aimed at evaluating the efficacy of different designs of AFOs and comparison between them on the gait parameters of individuals with hemiplegic stroke.
Methods: The search strategy was based on the population intervention comparison outcome (PICO) method. A search was performed in PubMed, ISI Web of Knowledge, Scopus, Science Direct, and Google Scholar databases.
Results: A total of 27 articles were found for the final evaluation. All types of AFOs had positive effects on ankle kinematic in the first rocker and swing phases, but not on knee kinematics in the swing phase, hip kinematics or the third rocker function. All trials, except two, assessed immediate or short-term effects only. The articulated passive AFO compared with the non-articulated passive AFO had better effects on some aspects of the gait of patients with hemiplegia following stroke, more investigations are needed in this regard though.
Significance: An ankle-foot orthosis can immediately improve the dropped foot in the stance and swing phases. The effects of long-term usage and comparison among the different types of AFOs need to be evaluated.

1. Introduction

Stroke (cerebrovascular accident) is one of the main causes of mortality throughout the world [1]. Individuals with stroke and other neurological disorders have reduced walking capacity, which has a great impact on the daily life. Subjects' gait following the stroke is characterized by reduced walking speed, increased energy cost, asymmetry, foot drop, and insufficient muscle activity in the stance phase [2–6]. Regaining independent safe mobility is the frequent aim of stroke rehabilitation and an ankle-foot orthosis (AFO) is often used to improve mobility and balance as a part of this program [7].

Almost all the AFO designs reviewed in this paper limit plantar flexion with the extent of dorsiflexion depending on the design. In general, there are 3 types of AFOs: passive, semi-active, and active. Active and semi-active AFOs contain onboard power source, sensors, control systems, and actuators. Among these AFOs, passive devices are the most popular daily-wear device due to its durability, and simplicity of the design. Passive devices are 2 types: articulated and non-articulated. Non-articulated AFOs are usually 1 piece, made of lightweight thermoplastic or thermoformable materials, and encompass the dorsal part of the leg and bottom of the foot. These non-articulated AFOs include: posterior leaf spring AFO (PLS AFO), carbon fiber AFO (CAFO), rigid AFO (RAFO), anterior AFO (AAFO), and dynamic supramalleolar AFO. Passive articulated AFOs have different designs of articulated joints with a variety of hinges, flexion stops, and stiffness control elements such as spring and oil damper. These AFOs include: plastic or metal AFO with plantarflexion stop and dorsiflexion free (AFO-PS), chignon AFO and oil-damper AFO (AFO-OD) [8].

The only other systematic review of the effects of AFOs in stroke also reported a beneficial effect on gait [9–11]; however, it did not compare different designs, define optimal designs, and establish algorithms to effectively select the optimal design of AFO for the patients with stroke and different levels of injury. Thus, the current review aimed at conducting a systematic review to determine the effect of different designs of AFO on the gait parameters (in terms of kinematics, kinetics, and muscle activity) in adults with stroke. Specifically, the current review addressed the following questions: [1] Effect of the non-articulated AFOs on the gait function of patients with stroke. [2] The

Abbreviations: AFO, ankle-foot orthosis; PLS AFO, posterior leaf spring AFO; CAFO, carbon fiber AFO; RAFO, rigid AFO; AAFO, anterior AFO; AFO-PS, hinged plastic or metal AFO with plantarflexion stop and dorsiflexion free; AFO-OD, oil-damper AFO; PSw, preswing; LR, loading response

* Corresponding author. Department of Orthotics and Prosthetics, University of Social Welfare and Rehabilitation Sciences, Kodakyar St., Daneshjo Blvd., Evin, Tehran, 1985713834, Iran.
E-mail address: M.arazpour@yahoo.com (M. Arazpour).

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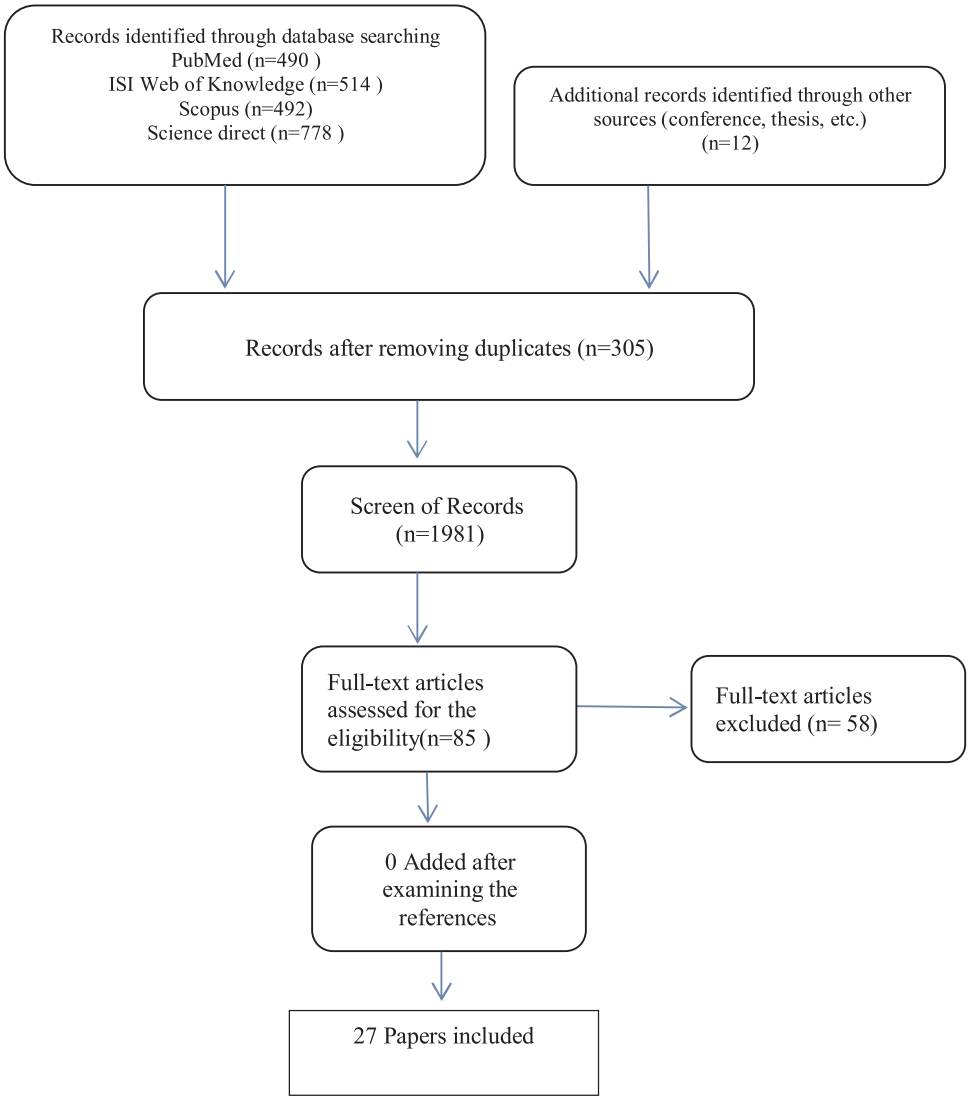

Fig. 1. The procedure was followed using the PRISMA method.

effect of articulated AFOs on the gait functions of patients with stroke, [3] Comparison between articulated and non-articulated AFOs on the gait function of patients with stroke.

2. Methods

2.1. Search strategy

The search strategy was based on the population intervention comparison outcome (PICO) method and included all relevant articles published from 1990 to March 2017. The procedure was, then, followed using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) method (Fig. 1). The ISI web of knowledge, PubMed, Scopus and Google Scholar databases were searched using the following keywords:

Participant-related: hemiplegi*, stroke, cerebrovascular accident, CVA

Intervention-related: AFO, caliper, ankle foot orthos*, brace, orthotic

Outcome-related: gait, walking, kinematic, kinetic, ground reaction force, moment, power, joint angle, EMG, muscle activity

The titles, abstracts, and full texts of the articles were reviewed by 2 researchers to select the ones that met the inclusion criteria and extract the data. Decisions about which papers to select were conducted by negotiation.

2.2. Study types

The current review included controlled trials compared walking with AFO and walking with no AFO (barefoot or with shoes), or compared the different designs of AFOs. Studies which used other types of orthoses such as knee orthosis, knee ankle foot orthosis, powered AFO, air-pressure splints, and strapping were excluded. Single-case, case reports, case-series designs, and uncontrolled trials were excluded due to the high risk of bias in such designs. Abstract-only reports were considered if there was no accompanying full text and if enough information could be received from the authors. Studies published in English language journals were selected.

2.3. Study selection

In the current review, studies were eligible for the inclusion criteria if they had the following data in the title or abstract: 1) Participants were the patients with stroke or the ones with other conditions if at least 50% of the subjects were stroke survivors; 2) The intervention included the types of the non-articulated passive AFOs, and the types of the articulated passive AFOs; [3] Outcome measures of the gait (kinetic, kinematic, and muscular activity), and [4] the statistical analysis of