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Review Article

Effects of Ankle Foot Orthoses on Restricted Ankle Joint Dorsiflexion Due to Plantarflexors Stiffness in People with Stroke: A Scoping Review

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ABSTRACT

Background: Orthotic interventions such as different types of ankle foot orthoses have been widely suggested to either prevent or treat restricted ankle joint dorsiflexion and consequent equinus or equinovarus foot deformities in people with stroke. However, it is not clear whether orthotic interventions are effective against spasticity or stiffness. Therefore, this systematic review aimed to systematically review the effect of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness.

Review of literature: An electronic database search was performed using PubMed, ISI web of sciences, Scopous within 1990-2018. A set of search terms were derived from medical subject heading (MESH). A total of 486 potential articles were identified through database search. Following title screening and reviewing abstract, 60 articles were potentially relevant to undergo full consideration. Full text article review counted this number down to 2.

Discussion: Studies found significant decreased plantarflexor stiffness indicated by increased ankle passive dorsiflexion range of motion after orthotic interventions.

Conclusion: There are only a few studies which have objectively assessed the effects of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness in stroke. A comprehensive study would provide insight into the effectiveness of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness.

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Background

Stroke or cerebrovascular-accident (CVA) is the leading cause of serious, long-term disability in adults which frequently leads to restricted movements and activities. It has been reported that CVA negatively affects mobility such that about 50% of people with stroke achieve only a limited level of functional mobility [1].

A combination of motor, sensory, visual, and cognitive impairments is the most frequently reported clinical picture of stroke as one of the upper motor neuron syndromes (UMN). These clinical features can be divided into three main broad categories: positive, negative and adaptive features [2]. Increased understanding of the complexity of physiological and adaptive mechanisms of soft tissues in UMN conditions suggest that the movement dysfunction seen by clinicians and commonly labelled as spasticity may actually be related to adaptive changes occurring in the tendon-muscle units, such as passive stiffness of the soft tissues [3, 4]. Plantarflexor stiffness or contracture on the affected side is one of the most important disabling adaptive features defined as increased resistance to passive dorsiflexion of the

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ankle due to the increased mechanical resistance to a lengthening load on the non-contracting muscle [5]. Plantarflexor stiffness restricts ankle joint dorsiflexion and prevents the heel contacting the floor during stance phase and also may cause abnormal foot supination.

Foot and ankle complex stiffness in conjunction with spasticity has been reported to frequently cause restricted ankle joint dorsiflexion and consequently a range of foot deformities such as equinus and equinovarus eventually culminating in limited functional mobility. The main feature of equinus is restriction of ankle dorsiflexion due to shortening of plantarflexor unit and stiffness of surrounding tissues [6].

Many rehabilitation techniques and modalities have been widely used to address restricted ankle joint dorsiflexion by working on stiffness and spasticity. Stretching has been reported as one of the effective interventions to address these deficits [7]. People with stroke are normally required to attend regular physical therapy sessions to benefit from stretching and similar techniques. However, it is not convenient for many patients to attend regular rehabilitation programs. Orthotic interventions such as different types of ankle foot orthoses (AFOs) or serial casting have been widely suggested to either prevent or treat restricted ankle joint dorsiflexion and subsequent equinus or equinovarus foot [8]. However, it is not clear whether orthotic interventions could influence plantarflexor spasticity or stiffness. Further, the pure effect of AFOs on either spasticity or stiffness has not been explicitly explained. Therefore, the aim of this systematic review was to systematically review the effect of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness.

Review of Literature

Search Strategy

To identify studies relating to the effect of ankle foot orthoses and serial casting on restricted ankle joint dorsiflexion due to plantarflexor stiffness in people with stroke, electronic database search was performed using PubMed, ISI web of sciences, Scopous within 1990-2018. A set of search terms were derived from medical subject heading (MESH). These databases were searched using a combination of search terms and synonyms as part of a title, abstract, and keyword search. To broaden the search strategy, sub search terms were truncated and wildcard symbols were applied. The search strategy included a combination of three groups of keywords as follows:

- Population related: "strok*", "cerebrovascular accident*", "hemipares*s", "hemiplegi*", "contractur*", "stif*" , and their synonyms.
- Intervention related: "orthos*s", "splint*", "shoe*", "cast*", "orthotic device*", "inlay", "insert", and their synonyms.
- Outcome measure related: "mobili*", "motion", "kine*", "range of motion", stretch*", and their synonyms.

A random search of online biomechanically–related journals was conducted to ensure the database search was sensitive to relevant articles. The final database search was completed only in English language.

Inclusion Criteria

To identify relevant studies, all titles and abstracts yielded from the search strategy were assessed by two reviewers. Studies were included for the subsequent quality assessment if the following criteria were all satisfied:

I- Human participant with stroke
II- Spasticity control
III- Main outcome measure related to stiffness
IV- Independent variable including either AFO or serial casting
V- Hypothesis testing with statistical analysis
VI- Participant sample size greater than N=1

Assessment of Methodological Quality

Study quality was assessed by two independent reviewers using Downs and Black's (1998) checklist [9]. Downs and Black reported a checklist applicable to both randomized and non-randomized trials. It involved 27 items concerning external validity, bias, confounding factors, statistical power, and reporting. After scoring by this checklist, disagreements on quality assessment were resolved through discussion and the final score was agreed upon.

Data Extraction and Analysis

A trained reviewer extracted data and a second reviewer verified the extracted data. Disagreements were resolved through discussion. Meta-analysis was not conducted due to the low number of studies (only 2) as well as due to the poor consistency of the data.

Results

Search Results

This study search gathered a total of 486 articles from all indexed database. After title screening, 60 studies were selected for full consideration. Two articles were suitable for initial conclusion (Figure 1).

Of these two selected articles, the first investigated the effect of an adjustable ankle foot orthosis on plantarflexion contractures. Grissom et al. [10] designed a nonrandomized interventional trial in which participants with stroke or head injury received a posterior tibial nerve block by lidocaine to assure differentiation between spastic deformity and true contracture. Then, the participants were fitted with adjustable orthosis for a minimum time of 23 hours per day for 14 days.

Yasar et al. [11] selected 10 chronic stroke subjects (more than 1 year). All subjects had equinovarus deformities and used cane as an assistance walker. They underwent BTX-A injection after which serial casting was applied on their affected limb. Ankle joint ROM was measured by goniometer just before injection and 24 days after injection and serial casting. A description of the included studies is provided in Table 1.

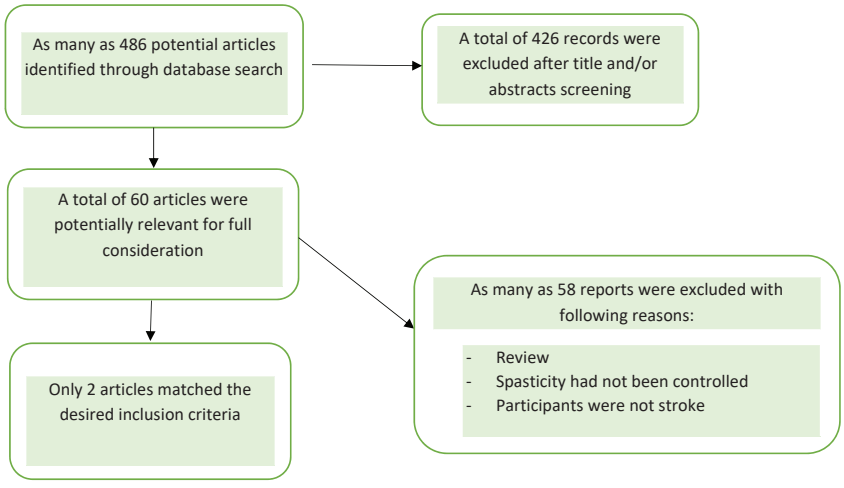

Figure 1: Flowchart of the study selection process

Table 1: Description of the included studies

Study	Subjects	Intervention	Study design	Outcome measure
Grissom et al. 2001	6 stroke or head injury cases	Lidocaine injection AND adjustable ankle foot orthosis	Prospective, nonrandomized, interventional trial	Dorsiflexion PROM at the ankle with the knee extended
Yasar et al. 2010	10 stroke cases	BTX-A injection AND Serial casting	Nonrandomized	Passive ankle dorsiflexion was measured goniometrically with full knee extension.

Quality Assessment

Study quality was assessed by two independent reviewers using Downs and Black's checklist. The mean methodological scores of the first and second studies were 16 of 27 and 17 of 27, respectively. Agreement between quality assessors was 100%.

Discussion

The aim of this systematic review was to systematically review the effect of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness. Increased muscle stiffness in the absence of reflex activity is one of the most reported complications after stroke which is caused by adaptive changes in intrinsic mechanical properties of muscles and tendons due to some factors such as immobility or prolonged shortening of muscles [2]. Note that it usually makes a significant contribution to joint stiffness. Increased stiffness in the affected ankle due to non-reflex changes in both dorsiflexors and plantarflexor restricts ankle joint movement and contributes to locomotor abnormalities post stroke [12-15]. A range of foot and ankle pathologies including equinovarus contracture and pronated foot have been attributed to the increased stiffness of plantarflexor among other conditions [16, 17]. In the stroke population, considerable attention has been directed toward understanding the role of plantarflexor stiffness as one of the underlying mechanisms of restricted ankle joint dorsiflexion and subsequent deformities such as equinovarus or equinus deformities [18]. However, little is known about the effect of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness. There were an insufficient number of studies on people with stroke investigating the effect of ankle foot orthoses on plantarflexor stiffness in which appropriate methods had been implemented to assure differentiation between spastic deformity and true stiffness. Only two articles fulfilled the desired inclusion criteria. Both studies found significantly increased ankle passive dorsiflexion range of motion (PDROM) after orthotic interventions.

It is unknown whether an ankle-foot orthosis prescribed to prevent or reduce restricted ankle joint dorsiflexion due to plantarflexor stiffness could impact the patients' gait pattern in the long term, or whether the patient adapts to the ankle-foot orthosis and returns to their previous pattern. Alternatively, long-term use could facilitate motor learning which would enable the patient to walk with an improved gait pattern once the ankle-foot orthosis is removed. There is much to understand about the role of orthoses for the prevention or alleviation of stiffness of plantarflexors after stroke. For example, we do not know how long the device needs to be worn in total and also during a 24-hour period in order to be effective. It is also unclear how long the orthosis should be worn on limb with no side effects such as muscle atrophy, decreased bone mass, and skin breakdown.

Several limitations in the final two studies were evident. The major flaws were lack of a control group and low overall quality of studies. Other limitations included non-randomized nature of the studies and a small number of participants, as well as lack of long-term follow-up.

Conclusion

In conclusion, there are only few studies which have objectively assessed the effects of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness in stroke. These studies worked on very few

and heterogeneous study samples and measurement tools. A comprehensive study would provide insight into the effectiveness of orthotic interventions on restricted ankle joint dorsiflexion due to plantarflexor stiffness. It could also provide a potential for future development of interventions and guidelines to help prevent or treat these abnormalities with the final aim of enhancing functional ability and ultimately quality of life for the stroke population.

Conflict of interest: None declared.

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