A Critical Consideration on Common Orthotic Treatment Concepts for Gait Problems in Cerebral Palsy

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Introduction
The goal of an orthotic treatment in cerebral palsy (CP) is to come closer at best to a physiological gait. According to the Amsterdam Gait Classification, the pathological gait patterns of CP patients are divided into five gait types. This classification must be considered for an optimal care. During swing phase an ankle foot orthosis (AFO) prepares the foot for *initial contact* (IC). It also enables a better stability and supports the ankle's push off during stance phase. Besides, an AFO should have a positive effect on therapy and must not lock residual physiological motion. A detailed consideration of existing orthosis types should indicate whether the requirements for all gait types can be met.

Materials and Methods
The effect of already existing AFO is evaluated. Considering the criteria of adjustable alignment, pivot point, range of motion and spring force, supramalleolar orthoses, solid AFO (SAFO), dynamic AFO (DAFO), floor reaction AFO (FRAFO), posterior leaf spring AFO (PLS AFO) and hinged AFO (HAFO) are compared with each other.

Results
The alignment of most of the compared orthoses cannot be subsequently adjusted. In HAFO this is only possible to a limited extent depending on the joint type used. In PLS AFO, FRAFO and DAFO a defined pivot point is missing, while in HAFO it can be placed on the anatomical pivot point. Nevertheless, all orthoses lock the plantar flexion or just allow it through active muscle work. The range of motion is not possible, except for certain joint types (HAFO). In PLS AFO, FRAFO and DAFO the spring force can only be regulated by the material and its thickness used during producing. Elastomer spring or coil spring joints that are mounted in a HAFO have too low spring forces.

Discussion
Due to an appropriate orthosis, coming closer to a physiological gait and improving the energy consumption of CP patients are possible. Depending on the gait type, different AFO are used for the treatment. Already existing AFO do not fulfil all necessary requirements because basic adjustment possibilities are missing. The spring force needed to be applied to the ankle by an AFO depends on the gait type as well as on the anthropometric data of the patient. The correct alignment of the orthosis using biomechanical principles is essential for a successful orthotic treatment. The remaining function of the muscles involved is used to provide the nervous system with proprioceptive input. This process is known as neuroplasticity and takes place especially during plantar flexion in IC. Therefore, the resulting demand is: Both dynamic and static AFO should be produced with an adjustable ankle joint. The optimal ankle joint for a HAFO should dispose of three adjustments that can be changed separately and do not influence each other: 1. spring force, 2. alignment of the orthosis and 3. range of motion.

Keywords
Cerebral palsy, ankle foot orthosis, alignment, gait type, neuroplasticity

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