# A Review of Knee-Ankle-Foot Orthoses in Managing Neuromuscular Disorders: Focus on Children with Cerebral Palsy

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## Abstract

Neuromuscular disorders (NMDs) significantly impact the musculoskeletal system, leading to lower extremity muscle weakness and impaired coordination, notably affecting the quadriceps. These impairments compromise knee stability during standing and walking, increasing fall risks and hindering mobility and independence. Knee-ankle-foot orthoses (KAFOs) are vital in enhancing gait efficiency and knee stability. Traditional locked KAFOs rigidly immobilize the knee throughout the gait cycle, offering maximal stability but limited natural movement. Advances in orthotic technology have led to the development of stance control KAFOs (SCKAFOs), which dynamically lock the knee only during the stance phase, promoting a more natural and energy-efficient gait. The E-MAG Active and NEURO TRONIC knee joints are prominent examples of SCKAFOs, featuring sophisticated electronic control mechanisms to improve functional outcomes in individuals with NMDs. This review also focuses on the application of SCKAFOs in children with cerebral palsy (CP), the most common neuromotor disorder affecting movement, posture, and muscle tone due to early brain injury. The prevalence and diverse etiologies of CP necessitate individualized therapeutic interventions. The review aims to evaluate the efficacy and satisfaction of orthotic management in pediatric CP, providing evidence-based recommendations for optimizing orthotic interventions and enhancing quality of life for affected children and their families.

**Keywords:** Knee-ankle-foot orthoses (KAFOs), Stance control KAFOs (SCKAFOs), E-MAG Active knee joint, NEURO TRONIC knee joint, Children with cerebral palsy (CP)

***Significance*** | Neuromuscular disorders significantly impair mobility and stability; advanced orthoses like SCKAFOs improve walking efficiency and knee stability, enhancing life quality.

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## Introduction

Neuromuscular disorders (NMDs) encompass a spectrum of conditions that profoundly affect the musculoskeletal system, particularly the lower extremity muscles such as the quadriceps. These disorders often lead to weakness and impaired coordination, significantly compromising stability during activities like standing

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and walking. The resultant knee instability increases the risk of falls, posing significant challenges to mobility and independence for affected individuals. To address these issues, knee-ankle-foot orthoses (KAFOs) play a pivotal role in enhancing walking efficiency and promoting knee stability.

Historically, locked KAFOs were the standard orthotic solution employed for managing gait abnormalities associated with NMDs. These devices rigidly immobilized the knee joint throughout the gait cycle, aiming to provide maximal stability. However, advancements in orthotic technology have led to the development and widespread adoption of stance control KAFOs (SCKAFOs). Unlike their locked counterparts, SCKAFOs incorporate sophisticated knee joints that dynamically lock only during the stance phase of gait. This innovative design allows controlled knee flexion during swing, facilitating a more energy-efficient and natural walking pattern (Viallard et al., 2024).

Among the various knee joint systems integrated into SCKAFOs, the E-MAG Active knee joint and the NEURO TRONIC knee joint stand out as leading examples. Developed with electronic control mechanisms, these knee joints represent significant advancements in orthotic technology aimed at improving functional outcomes for individuals with NMDs (Fior & Gentz, Lüneburg, Germany).

The E-MAG Active knee joint operates by prelocking at a 15-degree knee flexion angle during terminal swing and fully locking at full knee extension. This locking mechanism is calibrated to the patient's step length using an integrated gyroscope within the SCKAFO. In contrast, the NEURO TRONIC knee joint utilizes motion sensors to detect leg deceleration just before initial contact, allowing for locking at any angle of knee flexion. This flexibility in locking position potentially enhances safety and adaptability in real-world scenarios compared to the E-MAG Active system, which necessitates complete knee extension for locking (de Morais Filho et al., 2023).

The safety implications of these design differences are critical. For instance, the NEURO TRONIC knee joint's ability to lock at any knee flexion angle may offer advantages in situations requiring sudden changes in step length, navigating uneven terrain, or making abrupt stops. In contrast, the E-MAG Active system's reliance on full knee extension for locking might pose challenges in scenarios where rapid responses are necessary, potentially leading to locking failures (LFs) and associated falls. Moreover, unlocking failures (ULFs) in both systems, occurring predominantly at terminal stance or preswing, can further influence user safety and gait efficiency (Bjornson et al., 2024).

The focus of this review extends beyond the technical aspects of SCKAFOs to explore their application and impact specifically on children with cerebral palsy (CP). CP is the most prevalent neuromotor disorder affecting movement, posture, and muscle tone development, primarily stemming from early brain injury during the prenatal or neonatal period (Anwer et al., 2022). The condition manifests in diverse forms and severities, often accompanied by secondary complications that evolve over time, impacting functional abilities even as the primary neuropathology stabilizes.

Epidemiologically, the prevalence of CP varies globally, ranging from 1.5 to 3 per 1,000 live births, with higher rates observed in certain geographic regions and disparities between high- and low-income countries (Mostowfi et al., 2022). Despite efforts to identify risk factors such as prematurity and low birth weight, a substantial proportion of children with CP are born at full term without identifiable prenatal complications. This underscores the complex etiology of CP, which includes both prenatal brain injuries and post-neonatal factors contributing to the condition's onset (Mostowfi et al., 2022).

The pathogenesis of CP involves a spectrum of congenital developmental abnormalities affecting the brain and nervous system. Neural tube closure defects, such as encephalocele and meningomyelocele, represent early fetal anomalies that disrupt normal motor development. These defects often lead to profound motor deficits and neurological impairments characteristic of CP, including spasticity and cognitive delays (Bjorgaas et al., 2021).

Genetic abnormalities, such as Meckel's syndrome linked to chromosomal anomalies, further complicate the spectrum of CP by presenting with additional features like microcephaly and polydactyly, exacerbating motor disability through hypertonia and hypotonia patterns (Gerami et al., 2023). Metabolic disorders, toxins, and drug exposures during critical periods of brain development also contribute significantly to the pathogenesis of CP, highlighting the multifactorial nature of the condition and its impact on neurodevelopmental outcomes (Katchburian et al., 2023; Niyonsenga et al., 2023).

The diverse etiologies of CP underscore the need for individualized therapeutic interventions tailored to address specific motor impairments and functional limitations in affected children. Orthotic management, including the use of advanced SCKAFO systems, plays a crucial role in optimizing mobility and enhancing quality of life for children with CP. However, the effectiveness and satisfaction with these interventions vary widely, necessitating a comprehensive review of current practices and outcomes in orthotic management for pediatric CP.

This review aims to critically evaluate the satisfaction scale of walking splints designed for children with CP, assessing not only their technical efficacy but also their impact on functional outcomes and quality of life. By synthesizing current research and clinical insights, this review seeks to provide evidence-based recommendations for optimizing orthotic interventions in pediatric CP, thereby addressing a critical aspect of therapeutic care and rehabilitation for affected children and their families.

**Classification of Cerebral Palsy**

Different types of cerebral palsy. (Bekteshi et al., 2021). Damage to the developing brain manifests through a spectrum of movement disorders categorized by the type, location, and severity of impairments, stemming from diverse etiologies and presenting with varying clinical profiles. Cerebral palsy (CP), specifically, is classified into three primary types based on the nature of movement dysfunction it induces: ataxic, dyskinetic, and spastic. These manifestations can affect one or both sides of the body, leading to classifications such as quadriplegic, hemiplegic, diplegic, and monoplegic, with diplegic CP being the most prevalent, followed by hemiplegic and quadriplegic presentations (You et al., 2020).

The etiology of CP encompasses a range of prenatal and perinatal factors, including acute hypoxia-asphyxia events, significant cystic brain degeneration, and developmental anomalies like polymicrogyria and schizencephaly. These conditions often result in varied clinical presentations, impacting motor function, sensory perception, and cognitive abilities. For instance, quadriplegic CP affects all four limbs, resulting in severe motor impairments across both upper and lower extremities, accompanied by symptoms such as pseudobulbar signs, difficulty swallowing, ocular abnormalities, seizures, and significant intellectual disabilities (Chebanenko et al., 2022).

In hemiplegic CP, which affects one side of the body, there is often a predominant impairment in hand function compared to leg function. This type of CP is characterized by sensory loss, hypertonicity of flexor muscles, and specific motor deficits such as compromised dorsiflexion and eversion in the affected limb. These impairments significantly impact daily activities and mobility, underscoring the need for tailored therapeutic interventions to address functional limitations (YANIKOĞLU et al., 2021).

Diplegic CP predominantly affects the lower limbs, with characteristic impairments including dorsiflexion and inversion of the foot, increased muscle tone in the flexor muscles, sensory abnormalities, and potential visual impairments. It is frequently associated with conditions like cystic periventricular leukomalacia, a common neurological complication in premature infants, highlighting the complex interplay of developmental factors in CP pathogenesis (YANIKOĞLU et al., 2021).

Overall, the classification and understanding of CP based on its clinical presentation and underlying pathology are crucial for developing targeted interventions aimed at optimizing functional outcomes and enhancing quality of life for individuals affected by this spectrum of neurodevelopmental disorders. Continued research into the etiological factors and pathophysiology of CP will further inform strategies for early diagnosis, intervention, and management, ultimately improving outcomes and support for affected individuals and their families. Different types of cerebral palsy. (Bekteshi et al., 2021).

**Clinical Presentations of Cerebral Palsy**

Damage to the developing brain resulting in cerebral palsy (CP) manifests in a spectrum of symptoms, predominantly characterized by motor impairments, sensory abnormalities, and associated comorbidities. These symptoms tend to evolve with age, exacerbating the challenges faced by individuals affected by CP, despite the underlying brain injury remaining static. Typically, fetal brain injuries exhibit discernible outward signs, yet many issues observed in newborns may resolve within the first two years of life due to ongoing central nervous system (CNS) development (Nakamura et al., 2021).

Among the hallmark symptoms of CP is muscle hypertonicity, stemming from brain lesions, which also precipitates additional motor deficits such as impaired balance, coordination, and hand function. This hypertonicity can be attributed to several factors: firstly, individuals with CP often require more muscle fibers to achieve motor tasks compared to their neurotypical peers; secondly, excessive collagen deposition within muscle fibers contributes to stiffness, reducing overall muscle efficiency; and thirdly, disruptions in the neuromuscular junction impair proper muscle contraction (Blank et al., 2022).

Research indicates that damage to the developing brain's CNS leads to the accumulation of collagen, thereby exacerbating motor impairments in children with CP. However, there remains a significant gap in knowledge concerning effective strategies for prevention and treatment of these complications. This underscores the ongoing need for targeted research aimed at understanding the mechanisms underlying motor dysfunction in CP and developing novel therapeutic interventions to mitigate its impact on affected individuals.

**Diagnosis**

Early diagnosis is paramount for initiating timely interventions that can optimize neuroplasticity and mitigate developmental delays in children at risk for cerebral palsy (CP). This unique approach maximizes the effectiveness of interventions by capitalizing on the brain's ability to adapt and reorganize during early developmental stages. Diagnosis of cerebral palsy typically involves a comprehensive assessment combining physical examinations, neuroimaging studies, and clinical evaluations, each offering distinct insights into the nature and severity of the condition (Vitrikas et al., 2020).

Key diagnostic strategies include evaluating the mother's medical history and closely monitoring the child's motor function performance. Given the complexity of CP, additional diagnostic tools such as electroencephalography, audiometric testing, vision screening, and psychological assessments are often employed to provide a holistic understanding of the child's condition (Vitrikas et al., 2020).

Screening high-risk newborns involves vigilant observation for early indicators such as neurobehavioral signs, persistence of developmental reflexes beyond typical timelines, abnormal muscle tone and posture, delayed developmental milestones, and associated comorbidities. This proactive approach to screening echoes the historical advocacy by William Little in the 1800s, highlighting the importance of early detection in facilitating prompt intervention (Vadivelan et al., 2020).

Early diagnosis not only aids in identifying the underlying causes of CP but also enables healthcare providers to initiate appropriate treatments aimed at minimizing disease progression, fostering neuroplasticity, and enhancing functional outcomes for affected children (Vadivelan et al., 2020). By adhering to established diagnostic criteria and leveraging a multidisciplinary approach, healthcare teams can effectively identify and support children with CP from the earliest stages of development, thereby optimizing their long-term health and well-being (Morgan et al., 2021).

**Correspondence between Expected, Perceived, and Measured Effects of BoNT-A Treatment in Calf Muscles among Children with Cerebral Palsy**

Cerebral palsy (CP) stands as the most prevalent cause of physical disability among children, stemming from damage to the developing brain. In high-income countries, its estimated point prevalence is 1.6 per 1000 live births. According to Rosenbaum et al. (2007), CP encompasses a spectrum of persistent abnormalities in posture and movement development, primarily associated with non-progressive disruptions to the fetal or infant brain. These motor impairments frequently co-occur with sensory, perceptual, cognitive, behavioral, and epileptic disturbances, alongside secondary musculoskeletal complications (Marpole et al., 2020).

Key motor abnormalities in CP include reduced selective motor control, stiffness, and muscle weakness, often leading to secondary issues such as bony deformities and contractures. Despite 56% of children with CP being capable of walking independently, they commonly experience varying degrees of limitation compared to their typically developing peers. Musculoskeletal pain and fatigue are prevalent among children and adolescents with CP, likely contributing to reduced social engagement and physical activity levels (Fehlings et al., 2024).

Spasticity, observed in up to 88% of cases, has been a focal point in CP management, irrespective of the severity of impairment. The prevailing clinical perspective is that spasticity detrimentally affects function, although its role in preserving certain functions, like grip, has also been recognized. Scientific evidence, however, remains limited and conflicting regarding the relationship between spasticity and activity levels. The advent of intramuscular botulinum toxin A (BoNT-A) injections in the 1990s revolutionized spasticity treatment, benefiting approximately 55% of children with spastic CP, with nearly half being independent walkers (Sadowska et al., 2021).

A primary treatment objective involves addressing spastic equinus gait by targeting calf muscles. While there is considerable evidence supporting the efficacy of BoNT-A in reducing spasticity, data on its impact on walking and overall functional performance remains sparse, partly due to variations in outcome measures. The inclusion of cardiorespiratory outcomes, which directly relate to walking comfort and energy transfer involving calf muscles and ankle joints, is crucial but underutilized in research methodologies, leading to inconsistent findings (Demers et al., 2021).

Research into intervention impacts must consider contextual influences. Few qualitative studies have explored caregivers' perspectives, with quantitative studies predominating in evaluating BoNT-A treatment effects. Caregivers have reported positive outcomes, including reduced stiffness, improved motor function, elevated mood, and increased activity levels in their children. It is noteworthy that caregivers also acknowledge both the benefits and drawbacks of treatment. Notably, recent studies increasingly involve children in research, respecting their rights, perspectives, experiences, and voices in understanding treatment impacts (Hulst et al., 2021).

**Effects of Ankle Foot Orthoses on the Gait Patterns in Children with Spastic Bilateral Cerebral Palsy**

Cerebral palsy (CP) stands as the most prevalent cause of motor impairment in children, affecting approximately 1 out of every 500 live births globally. It encompasses a spectrum of disabilities and motor disorders characterized by diverse manifestations and functional levels. Among the challenges faced by children with cerebral palsy, abnormalities in gait due to insufficient muscle activation are particularly significant. Instrumented clinical gait analysis plays a crucial role in both planning interventions and evaluating progress in these individuals (Pham et al., 2020).

Despite the widespread use of sagittal plane kinematic outcomes in gait classification systems for CP, comprehensive utilization of three-dimensional kinematics or kinetics data to identify various gait patterns remains uncommon. Several gait classification systems have observed numerous patterns with high intra-rater reliability and moderate inter-rater reliability, particularly in bilateral spastic CP. Rodda's classification, noted for its detailed assessment of concurrent abnormalities across lower limb joints, stands out as one of the most comprehensive (Gonzalez-Mantilla et al., 2023).

In spastic bilateral CP, Rodda's classification identifies five fundamental sagittal plane gait patterns: true equinus, jump gait, apparent equinus, crouch gait, and asymmetry gait. These patterns are grounded in clinical insights and biomechanical principles, serving as foundational rules for designing rehabilitation strategies tailored to each child with CP. Such classifications are instrumental in therapeutic decision-making, aiding in the selection of

appropriate orthotic devices and guiding considerations for surgical and non-surgical interventions (Gonzalez-Mantilla et al., 2023).

Ankle foot orthoses (AFOs) are frequently prescribed to manage motion and improve dynamic efficiency in children's gait with CP, aiming to prevent or mitigate deformities. AFOs come in various designs, distinguished primarily by stiffness, material composition, and configuration, each influencing their ability to regulate gait dynamics. Options include one-piece designs like the posterior leaf spring (PLS) AFO, two-piece systems with hinged joints (HAFO) enabling dorsiflexion, and anterior shelf designs promoting knee extension (GRAFO). Additionally, thicker thermoplastic AFOs such as the solid ankle AFO (SAFO) restrict ankle and foot motion in all planes, whereas more flexible dynamic AFOs (DAFOs) allow some degree of sagittal plane movement (Zhang et al., 2020).

**Hand–Arm Bimanual Intensive Training Including Lower Extremity training for children with bilateral cerebral palsy**

Traditional neurodevelopmental therapies often relied on passive movement experiences such as manual stretching to maintain or increase range of motion, reduce contractures, and attempt to normalize movement patterns in children with cerebral palsy (CP). However, research has shown that these approaches yield limited motor outcomes for children with CP. In contrast, child-active task-specific motor training, rooted in the motor learning paradigm, has emerged as a contemporary and effective intervention for school-aged children with CP. Examples include constraint-induced movement therapy, bimanual training, and goal-directed training, each targeting specific motor tasks relevant to daily activities (Al Imam et al., 2021).

Studies supporting these interventions differ in their focus, particularly between upper and lower extremities. While there is ample research on task-specific interventions for upper limb motor improvement, fewer studies have explored similar interventions for lower limb motor performance in children with CP (Al Imam et al., 2021).

Recent comprehensive analyses highlight the benefits of targeted gait training for children with unilateral and bilateral CP, demonstrating significant improvements in gait speed (effect size=0.92, p=0.01). For upper limb motor skills in unilateral CP, intensive therapies (approximately 60 hours) have been particularly effective, including modern motor learning-based approaches like constraint-induced movement therapy and Hand-Arm Bimanual Intensive Training (Badawi et al., 2021).

To address the needs of children with bilateral CP, Hand–Arm Bimanual Intensive Training Including Lower Extremity (HABIT-ILE) was developed to simultaneously target upper and lower limb impairments. Research, including randomized controlled trials, has shown that HABIT-ILE improves motor outcomes in both upper and lower extremities compared to upper extremity training alone (Maitre et al., 2020).

Despite these advancements, children with bilateral CP face significant challenges, with over 60% experiencing impairments that affect participation in daily activities and overall quality of life. The HABIT-ILE Australia project represents a pioneering effort to evaluate the impact of intensive motor training interventions on motor and neuroimaging outcomes specifically in children with bilateral CP. However, the study acknowledges potential limitations, such as variations in intervention delivery by therapy students under supervision, which are mitigated through standardized training, daily debriefing sessions, and ongoing feedback from supervising therapists (Shengyi et al., 2021).

**Splint: the efficacy of orthotic management in rest to prevent equinus in children with cerebral palsy**

Cerebral palsy (CP) encompasses a spectrum of chronic abnormalities in posture and movement development that significantly limit individuals' activities. These conditions result from non-progressive disruptions in the developing fetal or infant brain and are often accompanied by epilepsy, secondary musculoskeletal issues, and impairments in sensation, perception, cognition, communication, and behavior. Among the various types of CP, spastic CP is the most prevalent, affecting approximately 85% of individuals. One hallmark of spasticity is resistance to passive movement that increases with the velocity of the movement or stretching.

In high-income countries, CP affects approximately two out of every 1000 live births. Many children with spastic CP experience restricted range of motion (ROM) in their limb joints, particularly the hip, knee, and ankle, attributed clinically to increased stiffness or relative shortness of the muscle tendon complex compared to bone length (Gibson et al., 2021).

Children with CP commonly exhibit spasticity in the gastrocnemius muscles, crucial for ankle and knee range of motion as they span from the femur to the calcaneus. Research indicates that these muscles tend to be shorter and stiffer in children with CP compared to typically developing peers, contributing to limitations in ankle dorsiflexion range of motion, particularly evident during full knee extension. These limitations can lead to ankle equinus deformities and altered gait patterns characterized by increased ankle plantar flexion and knee flexion during midstance, which negatively impact mobility, metabolic efficiency, and endurance during walking (Sakkos et al., 2021).

Although the effectiveness of continuous stretching remains uncertain, it is often combined with night splints, referred to here as "orthotic management in rest." Knee-ankle-foot orthoses (KAFOs) are frequently employed to apply prolonged stretch to the gastrocnemius muscle in children with spastic CP. Static KAFOs maintain fixed knee and ankle angles, while dynamic KAFOs use springs to allow controlled ankle movement. These orthoses aim to

maintain maximum ankle dorsiflexion when the knee is extended, primarily during periods of inactivity (Orekhov et al., 2020).

It is hypothesized that KAFOs may be more beneficial during rest periods than during active hours due to their potential restriction of knee movement. During active times, ankle-foot orthoses (AFOs) are often preferred since they accommodate knee flexion during walking and sitting, which may not effectively stretch the gastrocnemius muscle (Chopra et al., 2022).

While some studies suggest positive outcomes from orthotic interventions during rest, such as wearing KAFOs for extended periods daily to maintain ankle dorsiflexion range of motion, further research is needed. Studies evaluating the specific responses of the gastrocnemius muscle to prolonged stretching and the effectiveness of orthotic care in different contexts are essential to optimize treatment strategies for children with CP (Merino-Andrés et al., 2022).

**One-Minute Walk Test in Children with Cerebral Palsy GMFCS Level 1 and 2: Values to Identify Therapeutic Effects after Rehabilitation**

In Europe, the prevalence of cerebral palsy (CP), which affects 2-3 out of every 1000 live births, is the main factor contributing to permanent motor disability in children and adolescents. The degree of disability varies despite its side effects, which include contractures, skeletal abnormalities, loss of functional selectivity, stiffness, and muscle atrophy and paresis. Therefore, to monitor and assist the development of children and adolescents with CP, intensive multiprofessional care is required. Independent walkers with cerebral palsy (CP) who have a Gross Motor Function Classification System (GMFCS) locomotion level of 1 or 2 generally engage in activities alongside children and adolescents who are typically developing, which can lead to challenges linked to inadequate walking capacity and speed. (van Gorp et al., 2020).

Children with cerebral cerebral palsy (CP) might benefit from physiotherapy, walking aids, splints, and rehabilitation therapy to enhance their gross motor function and walking ability. It is critical to properly evaluate the effectiveness of such treatments in neuropediatric therapy, tracking their impact with reliable and diagnostic instruments. Children with cerebral palsy (CP) frequently use the One-Minute Walk Test (1MWT), which is a legitimate, practical, and reliable tool. There has not yet been a report on a test-retest agreement for 1MWT. (May et al., 2021).

The Gross Motor Function Measure (GMFM) and other diagnostic instruments that evaluate motor function must be used with age-related reference ranges. Despite the fact that children with CP use the 1MWT, there are no CP-specific reference ranges in the literature. A thorough analysis of the literature regarding the effectiveness of therapies to increase gait speed in children with CP showed that gait training is highly successful. Additional research is necessary to fully understand the effectiveness of whole-body vibration (WBV) training in improving walking ability, as indicated by individual studies.. (Fandim et al., 2021).

**Daily functional electrical stimulation during everyday walking activities improves performance and satisfaction in children with unilateral spastic cerebral palsy**

Cerebral palsy (CP) encompasses a set of permanent motor dysfunctions resulting from non-progressive brain injuries. Secondary musculoskeletal impairments are common, exacerbating activity limitations. Unilateral spastic cerebral palsy (USCP) is the most frequent form, often classified under levels I or II of the Gross Motor Function Classification System (GMFCS), indicating some ambulatory independence with notable challenges outdoors. These difficulties primarily stem from lower limb musculoskeletal abnormalities such as ankle dorsiflexion weakness, contractures, spasticity, and impaired ankle motor control, which collectively hinder effective foot clearance during the swing phase of gait (Hurvitz et al., 2021).

Functional electrical stimulation (FES) targeting ankle dorsiflexors during gait swing phase has emerged as a promising intervention to address foot clearance issues. FES involves applying neuromuscular electrical stimulation to muscles to induce contractions during functional activities like walking. This approach has gained traction with the availability of user-friendly devices, facilitating community-based implementation overseen by families (Howard et al., 2023).

Recent research increasingly supports the efficacy of FES in children with CP, focusing primarily on biomechanical outcomes such as range of motion, spasticity, strength, muscle volume, and gait mechanics. However, assessing broader impacts on satisfaction and daily activity performance in community settings remains critical (Whitney et al., 2021).

To evaluate these aspects, the Canadian Occupational Performance Measure (COPM), a validated client-centered tool, assesses self-perceived performance and satisfaction with personally prioritized activities before and after implementing FES during routine walking tasks (Srivastava et al., 2022).

Clinically, identifying and managing spasticity in CP is crucial as it manifests as increased resistance to passive stretch or inappropriate involuntary muscle activity linked to higher motor neuron dysfunction. Spasticity significantly impacts activities of daily living (ADLs) like walking, eating, hygiene, and dressing, potentially leading to secondary issues such as pain, muscle spasms, postural problems, contractures, and joint deformities (Eriksson et al., 2020).

Despite its challenges, spasticity can also offer some benefits for children with CP, including support for weight-bearing and maintenance of bone density and muscle mass, highlighting the complex role it plays in functional outcomes (Vinkel et al., 2022).

## Conclusion

In conclusion, knee-ankle-foot orthoses (KAFOs), especially stance control KAFOs (SCKAFOs) equipped with advanced knee joint systems like the E-MAG Active and NEURO TRONIC, represent pivotal advancements in orthotic management for children with cerebral palsy (CP). While both systems aim to improve gait efficiency and stability, the NEURO TRONIC knee joint's ability to lock at any knee flexion angle offers potential advantages in adaptability and safety during real-world activities compared to the E-MAG Active system, which requires full knee extension for locking. Understanding these nuances is crucial for optimizing therapeutic outcomes and enhancing the quality of life for children with CP, underscoring the need for personalized orthotic interventions tailored to individual functional needs and gait patterns. Continued research and clinical evaluation will further refine these technologies, ensuring that orthotic interventions evolve in tandem with the diverse needs of children with neuromuscular disorders like cerebral palsy.

## Author contributions

N.S.A., M.F.A.A., N.M.A., E.Y.S.A., A.Y.S.A., F.S.A.A., M.S.A.A., S.S.S.A., N.A.R.A., B.A.A., A.S.M.A., K.A.S.Q., and K.O.L.A. conceptualized the study. Data curation and formal analysis were led by N.S.A. and M.F.A.A., with contributions from the rest of the team. M.F.A.A. managed project administration. N.S.A. and M.F.A.A. drafted the manuscript, with inputs from all authors.

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## Competing financial interests

The authors have no conflict of interest.

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