

Designing Orthotics to Better Mimic Normal Gait

By John Izak, CPO

As a practicing orthotist for nearly 20 years, I have developed a great passion for treating children with various disabling conditions. These children and their parents have been seeking all means possible to attain the ability to walk, play, and run. I have aligned myself with wonderful physical therapists and open-minded physicians that share in my goals and passion. Though I enjoy being a co-owner and practicing clinician in a successful orthotics practice, I struggle with the premise that the children I treat can do even better. It seems, despite the traditional orthotic interventions that I provide, that many of the children continue to return to unstable alignment and tightened musculature from heel to toe.

The advent of flexible devices and jointed devices has not been the total answer. In our attempt to rush and provide children of all ages and with many pathologies with free motion and articulating devices, we perhaps have caused more long term kinematic problems than we realize. I understand range



Working on weight shifting in orthotics.

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of motion is important in helping children achieve functional mobility; however, the dependency on assistive devices for gait and more medically invasive interventions to achieve anatomical correction is disheartening.

Recent, or I should say latent contributions, from colleagues in physical therapy have brought promising outcomes to pediatric care as we know it. Elaine Owen, MSc, SRP, MCSP, in Scotland has researched range of motion as it relates to the gastrocnemius muscle group in children with neuropathophysiological problems.¹ Her research shows that without adequate range of motion of the gastrocnemius muscle group, a child will have difficulty ambulating with or without the use of a device. Ms. Owen and her colleagues have found that

children respond better when her team included the R1 range of motion (first catch in full dorsiflexion with knee extension) in the planning and fabrication of the device.

Historically in traditional pediatric orthotic management, devices were fabricated as close to 90° neutral as possible without regard to standing sagittal alignment and its effects of forcing the knee straight. This 90° position was and continues to be seen as the way to prevent heel cord tightening and the way to position the ankle to initiate a normal heel strike. The problem is that the focus is below the knee only.

Ms. Owen's Scottish team has found that not only were children more tolerant of ankle foot orthoses (AFOs), but they also actually gained range of *(continued on next page)*

Designing Orthotics to Better Mimic Normal Gait (continued)

motion at the ankle when the gastrocnemius muscle group was stretched while wearing them. Furthermore, the Scottish group found that by using rigid orthoses aligned to the patients' R1 or soft R2, depending on spasticity, to establish orthosis alignment, the foot and ankle structure was stabilized, greatly reducing compensation all the way up the body. (R2 is the maximum end range with slow stretch.)

They then aligned the orthosis to the floor, finding that 10°-15° of tibial inclination (the angle of the shank [tibia] relative to the horizontal surface when standing in AFOs with heels down and weight equally distributed between heel and toe) provided the most effective and stable gait. The Scottish research team then worked with an algorithm of shoe design features that assist in achieving normal alignment for gait by further manipulating how the AFO – shoe combination reacts with the floor. If the ankle angle in the device is set without regard to the available gastrocnemius group R1 range of motion, there will be insufficient length to allow knee extension at initial heel contact and terminal stance, and compensations will occur. Ms. Owen is well published in her research on weight line transition work and her team's findings are deserving of reading.

The Serial Casting Program at Children's Memorial Hospital in Chicago is another wonderful program started nearly two decades ago that echoes these findings, but in a systematically different way. Mary Weck's physical therapy team, in conjunction with the hospital's orthotics department, has been helping children achieve independence with standing and walking for many years. Ms. Weck's program has also seen promising results when serial casts are applied respecting the R1 position of the gastrocnemius muscle group. The casting program may go many weeks and the protocol is typically followed by the use of day and/or nighttime devices. Ms. Weck's group monitors many measurements, including muscle circumference, range, and strength. Both work in Scotland and Chicago involve a strict

DRAFO System

- The DRAFO System Mimics gait biomechanics of normal human locomotion –
- The 3 foot rockers are incorporated into the orthosis
- 2nd rocker achieved by Tibial Alignment
- Stabilizes and maintains desired alignment without requiring excessive pressure
- Plantar aspect functions like a prosthetic foot



- **Forefoot design:**

- Posting designed to have dual function:
 1. Align forefoot
 2. Manipulate terminal stance
- Allows for functional 3rd rocker

- **Calcaneal Wrap**

- Locks in the Hindfoot
- Allows 1st Rocker at heel strike
- Achieves Stability at Heel Strike
 - Sach heel effect de-accelerator
 - De-rotator
 - Proprioceptive feedback



program of weight shifting and wearing schedules. The outcomes of both programs are promising.

WORKING ON WEIGHT SHIFTING IN ORTHOTICS

The devices used in both programs are typically solid AFOs. They are fabricated with respect to the current ankle positions present in the children. Although the outcomes from these two teams are worthy and very exciting, the practicality of shoe modifications (with Owen's program shoe modifications are necessary to affect the biomechanics of the shank through stance phase by manipulating loading response, mid-stance, and terminal stance) and availability of skilled serial casting may be difficult. Despite being difficult, this paradigm shift is necessary, in my opinion.

With the encouragement of many, including Beverly Cusick and me, Davin Heyd of Bracemasters Intl. has come up with a wonderful line of devices that embrace the weight line transitional work and incorporate the center of gravity work of both programs. These devices predominantly present as solid AFOs, but are enhanced in design by the use of flexible inner liner supramalleolar orthoses (SMOs) that includes an incredible trademarked soft open heel. Furthermore, when indicated, the forefoot alignment is posted and the uninvolved medial or lateral forefoot soft interface is exposed. Please see

Designing Orthotics to Better Mimic Normal Gait (continued)

the descriptive diagram on previous page.

The hopes of Heyd's Dynamic Response Ankle Foot Orthosis (DRAFO) is that limited R1s will also be posted for and that the exposed heel will get sensory feedback, improving R1 over time as established by the work of Weck and Owen. At the time of this publication, the DRAFO concept is undergoing comparative gait analysis at several centers with much anticipated promise for use throughout all pediatric care centers.

Initial results in my clinics have shown amazing differences in some children. For example, standing balance has increased and upper extremity tone has been reduced. I see that much reflection and understanding of the current literature and experiential work is required. I also recognize that a greater understanding and harmony of spasticity management on behalf of each individual team needs to be established in order for these programs to be successful in this paradigm shift. ■

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REFERENCES

¹ Owen E. *Shank angle to floor measures and tuning of ankle-foot orthosis footwear combinations for children with cerebral palsy, spina bifida and other conditions*. [MSc Thesis]. Glasgow, Scotland: University of Strathclyde; 2004.


SUGGESTED READINGS

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Owen E. The importance of being earnest about shank and thigh kinematics especially when using ankle-foot orthoses. *Prosthetics and Orthotics International*, 2010; 34 (3):254-269.



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These links offer clients, parents and caregivers access to reliable health care information and general advocacy resources.

Administration on Developmental Disabilities – The ADD is the U.S. Government organization responsible for implementation of the Developmental Disabilities Assistance and Bill of Rights Act of 2000, which ensures that individuals with developmental disabilities and their families participate in the design of and have access to culturally competent services, supports, and other assistance and opportunities that promotes independence, productivity, and integration and inclusion into the community.

American Academy for Cerebral Palsy and Developmental Medicine – The AACPM is a multidisciplinary scientific society devoted to studying cerebral palsy and other childhood onset disabilities, to promoting professional education for the treatment and management of these conditions, and to improving the quality of life for people with these disabilities.

American Academy of Neurology – The AAN is an international professional association of more than 18,000 neurologists and neuroscience professionals dedicated to providing the best possible care for patients with neurological disorders.

American Academy of Pediatrics – The AAP is dedicated to the health of all children. Its member pediatricians are committed to the attainment of optimal physical, mental, and social health and well-being for all infants, children, adolescents, and young adults.

American Occupational Therapy Association, Inc. – The AOTA is a nationally recognized professional association of approximately 40,000 occupational therapists, occupational therapy assistants, and students of occupational therapy. The AOTA mission is to advance the quality, availability, use, and support of occupational therapy through standard-setting, advocacy, education, and research on behalf of its members and the public.

American Physical Therapy Association – The APTA is a national professional organization representing more than 63,000 physical therapists, physical therapy assistants and students of physical therapy. The APTA mission is to further the profession's role in the prevention, diagnosis, and treatment of movement dysfunctions and to enhance the physical health and functional abilities of members of the public.


American Speech-Language-Hearing Association – ASHA is the professional, scientific, and credentialing association for more than 115,000 members and affiliates who are audiologists, speech-language pathologists, and speech, language, and hearing scientists. The ASHA mission is to promote the interests and provide the highest quality services for professionals and to advocate for people with communication disabilities.

Association of University Centers on Disabilities – The AUCD is a non-profit organization that promotes and supports a national network of interdisciplinary university centers that advance policy and practice for and with individuals with developmental and other disabilities, their families, and communities.

California State Council on Developmental Disabilities – The SCDD is a federally-funded independent state agency established in federal and state law to assist in planning, coordinating, monitoring and evaluating services for individuals with developmental disabilities and their families.

Exceptional Parent Magazine – EP's on-line resource continues to provide information, support, ideas, encouragement and outreach for parents and families of children with disabilities, and the professionals who work with them.

Family Village – The Family Village is a global community that integrates information, resources, and communication opportunities on the internet for persons with cognitive and other disabilities, for their families, and for those that provide them with services and support. Our community includes informational resources on specific diagnoses, communication connections, adaptive products and technology, adaptive recreational activities, education, worship, health issues, disability-related media and literature, and more.



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