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 then we realize. I understand range 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. 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 motion shifting in orthotics.
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 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
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.

John Izak is a certified prosthetist/orthotist (CPO). He graduated from Temple University and Northwestern University School of Medicine’s Prosthetics-Orthotics Program. He has practiced in the field for twenty years, and is co-owner and practitioner of Orthologix, a specialized orthotics and prosthetics practice serving patients in southeastern Pennsylvania, New Jersey, and Delaware. He can be reached at jizak@orthologix.com.

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
