Special Pull-Out Section

Evidence Note:
The Effect of Ankle-Foot Orthoses on Balance

Feature
Qualitative Understandings of the Lower Limb in Children with Bilateral Cerebral Palsy

Book Reviews
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Care of the Combat Amputee
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Message from the President

Those of you who know me know I have three awesome sons of whom I speak often. Recently Jack, my oldest, did something that made me think about how privileged I am to be part of the O&P profession. Specifically, it made me think about how our future leaders are developing, how they are integrating into the Academy, and how they will shape its future.

Jack is on an intramural flag football team. He isn’t the biggest or fastest kid on the team, but he works hard—really hard. The coach began to notice the growing potential in Jack and asked him to play quarterback in the next game. Jack ended up starting at three different positions over the course of the season: quarterback, kicker, and outside linebacker. He had become integrated into the team. He was proud of the team’s accomplishments and determined to see the team succeed. When the season was over, Jack was very upset because, as he said, “The team is breaking up, and I won’t be a part of it anymore.” Jack felt that it was a privilege to be a part of a team that worked so well together, a team that was better because Jack was a part of it.

My son’s experience made me think about the profession we have chosen and how we are addressing its future. He made me realize how integrated I am into the Academy’s structure and our profession, which has given me a sense of accomplishment and the chance to improve lives every day. He made me realize what a privilege it is for me to say, “I am a contributing member of the Academy.”

When I was a young practitioner, I was only focused on patient care. Someone in the Academy saw potential in me and asked me to sit on one of the Academy’s task forces, where I began to see how much more I could do. After completing my term on the task force, a former Board member suggested that my background in education could be helpful on another committee. Over several years and after participating in many areas of the Academy’s work, I was encouraged to run for the Board. Now as president, I sit as an ex-officio on all of the Academy’s councils, committees, and task forces. This offers me a global view of our profession and a deeper understanding of our members’ needs. I am in a position, like Jack’s coach, to seek out the potential within our membership and find new leaders who will improve the Academy because they are part of it.

Now, not everyone I meet wants, or has the time, to become an officer of the Academy. I understand that. But the reality is that by working on just one Academy committee, you will begin transcending the service you provide to your patients by providing a service to the profession. In addition, as you take on new responsibilities, you may find yourself seeing things from a new perspective—a more global perspective.

In the past few years, the Academy has branched out in many new directions at the request of our membership. As a volunteer-driven organization, to continue to meet the needs of our members, we always need new volunteers. Yes, the Academy does have a great full-time staff. However, in our organization, the members make policy. Much of our work is done by volunteers with a commitment to improving the profession.

At the national level, there are numerous opportunities to work within the Academy structure and give back to the profession. The Academy has several specialized committees and task forces, including the Fellow Committee, the Publications Committee, and the Licensure Task Force. Other more direct contributions can be made within our eight professional societies, at local chapter meetings, and as a mentor of the Women in Orthotics & Prosthetics Committee. We recently added another exciting committee—the Student/Resident Committee. This committee aims to attract younger practitioners and recruit students to become more involved in the Academy. It is my hope that these younger committee members will integrate into our profession by taking on new responsibilities and realizing that they are the future leadership of the Academy and its chapters.

I would like to see all of our membership, including our newest members, develop a more global appreciation and understanding of the O&P profession. By doing so, we all will realize that we are part of our profession and integrated into this Academy. We will continue to expand on the factors that make our profession great and, along the way, look to our young leaders and find ways to develop their potential.

Please let me know if you want to contribute or have ideas to continue to foster the work of the Academy. I can be reached via e-mail at mmuller@csudh.edu.
Physiotherapy and Occupational Therapy for People with Cerebral Palsy: A Problem-Based Approach to Assessment and Management

Editors: Karen J. Dodd, Christine Imms, and Nicholas F. Taylor
Publisher: Mac Keith Press; Number of pages: 320
Reviewed by: Brigid Driscoll, PT, CO

This text is a useful resource for physical and occupational therapists as well as other clinicians who provide care for individuals with cerebral palsy. The intervention process model, which is adapted from the Occupational Performance Process Model (Canadian Association of Occupational Therapists, 2002), is used throughout the text as a standardized guideline for patient evaluation and intervention. The model is a patient- and family-centered tool that allows clinicians to systematically follow a clinical reasoning process that includes initial assessment, intervention, and final evaluation of outcomes. It is based on an eight-step process that ultimately should resolve the initial goals and concerns of the patient, family, and treatment team. These steps include:

1. Initial data collecting.
2. Identifying concerns.
3. Identifying relevant theory.
4. Assessing of body structure/function, activity, and participation.
5. Identifying contextual factors.
6. Negotiating the management plan.
7. Implementing a plan.
8. Evaluating outcomes.

The intervention process model is used in all of the case-based chapters to outline the individual treatment methods. In addition, the book presents a thorough overview of cerebral palsy and its complexities. There is a detailed description of the Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System (MACS) to better classify an individual’s severity of impairment in respect to gross and fine motor skills while taking environment into consideration. The use of these assessment tools within the text for the case-based treatment methods to classify a patient’s level of dysfunction emphasizes their importance.

One of the most enlightening chapters in the text focuses on the family’s perspective in caring for a child with cerebral palsy. This section reminds clinicians that in addition to our physical evaluation and use of assessment tools, we need to listen to our patients’ and their families’ concerns to achieve outcomes that address everyone’s goals.

A general summary identifies commonly used physical and occupational therapeutic processes and interventions, such as neuro-developmental treatment (NDT), constraint-induced movement therapy, casting, and orthotic intervention. The book then transitions into 12 chapters of individual patient case studies that detail the different stages of the lifespan of an individual with cerebral palsy and proposed treatment plans. The text is very thorough in presenting appropriate therapeutic care and intervention for individuals with cerebral palsy at any age. The appendix is a valuable resource and provides brief descriptions of the different assessment tools outlined in these chapters. The plan and implementation of treatment are presented, demonstrating areas that may include therapeutic, orthotic, environmental, and equipment intervention. Progression of these treatment strategies is also presented based on patient progress, and then final outcomes are evaluated. Each chapter is systematically organized and provides a range of possible interventions specific to a variety of patients’ physical, environmental, and emotional needs.

The book offers a brief overview defining upper- and lower-limb orthoses. Additionally, a few of the case studies present examples of the types of orthoses used. Among these is a discussion regarding the progression of AFOs post single-event, multilevel surgery (SEMLS), beginning with ground-reaction AFOs, progressing to solid AFOs and then to articulated AFOs. The authors emphasize the importance of sufficient calf muscle strength and muscle tension before transitioning to articulated AFOs in order to provide an adequate plantarflexion knee extension couple.

In Summary: While primarily targeting physical and occupational therapists, this text provides a comprehensive overview of the diagnosis and care for individuals with cerebral palsy throughout their lifespan.
Care of the Combat Amputee

Senior Editors: Paul F. Pasquina, MD, and Rory A. Cooper, PhD
Publisher: Office of the Surgeon General at TMM Publications; Number of pages: 739
Reviewed by: Joseph B. Webster, MD

Care of the Combat Amputee is a comprehensive textbook that provides an in-depth and detailed review of all aspects of care for the combat amputee. The 28 chapters of this text cover every component of amputation care, from surgical considerations, to sports and recreational opportunities, to the future of amputee-care research. A variety of other trauma-related topics, including burns, traumatic brain injury (TBI), and spinal cord injury (SCI), are also addressed. The depth of this book is reflected in the fact that it includes more than 120 contributors from a wide variety of disciplines, both military and civilian. The majority of the chapters are written by multiple authors, and each of the authors provides a high degree of knowledge and expertise.

The strength of this book is the depth of its content as well as the broad variety of topics covered. The text is dense, but the chapters are organized and structured so that it is relatively easy to locate specific information. The illustrations are superb, and the tables and graphs are also complementary to the comprehensive text. The text is well referenced, with several chapters including more than 200 references.

If there is a weakness of the book, it may be the limited inclusion of orthotic-management topics even though the combat amputee commonly requires orthotic management of other injured, but non-amputated, limbs. Coverage of partial-foot amputation management is also relatively limited compared to other topics.

In Summary: This book is an essential reference text for all healthcare providers who are involved in the care of persons with traumatic amputations, whether the amputation is the result of a combat injury or other trauma. It is suitable for a variety of medical professionals, including prosthetists, physicians, nurses, physical therapists, occupational therapists, social workers, and care coordinators. The material included in the text is certain to be of value to providers in the Military Health System, those in the Veterans Health Administration, and those in private or academic practices.

Rehabilitation Outcome Measures

Author: Emma Stokes, PhD
Publisher: Churchill Livingston; Number of pages: 189
Reviewed by: Phil Stevens, MEd, CPO, FAAOP

Today’s healthcare market is characterized by increasing interest and emphasis on outcome measures and the justification of provided services. As a result, many in the orthotic and prosthetic community will soon need to familiarize themselves with the terms and processes that make up this movement. This text provides orthotists and prosthetists with a concise introductory resource to assist in the selection of outcome measures for various patient care scenarios.

In its introductory section, readers are exposed to some of the history and development of standardized outcome measures, the International Classification of Functioning, Disability and Health (ICF) as a guiding framework to the selection of outcome assessment tools, and broad discussions on why and how to implement appropriate outcome assessments into clinical practice.

The second section of the text is a concise review of the key statistical concepts associated with any given outcome measure. This is done through individual chapters devoted to reliability, validity, and measuring change, respectively.

The third section provides a “tool box” overview. The material is classified according to measures of mobility, physical activity, fatigue, and satisfaction. Each of these functional domains is treated, in turn as an individual chapter, with each chapter composed of a review of the various outcome measures that have been developed and evaluated to perform assessments within each domain. Thus, a clinician interested in measuring mobility can find a description of the modified Emory Functional Ambulation Profile, any associated academic publications, the patient populations for which it was developed, its clinical utility, what is required for its administration, its validities and reliabilities, and its ability to measure change. The same information is indexed for eight additional outcome measures that assess mobility. Similar information is included for five measures of physical activity, six measures of fatigue, six measures of patient satisfaction, and seven disease-specific measures.

The text concludes with a thorough appendix, broken down into the various functional domains described (mobility, physical activity, fatigue, etc.).

In Summary: This book represents an excellent single source for those clinicians interested in expanding their knowledge of established outcome measures or integrating outcome assessments into their practice environments.
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**Scope of Review**

This Evidence Note summarizes the effects that AFOs have on balance as reported in peer-reviewed studies. AFOs studied can be divided into two groups:

1. **Sports orthoses**—any device providing external support to the ankle to prevent injury or stabilize the joint after an isolated injury.
2. **Ambulatory orthoses**—devices intended for individuals with pathological conditions requiring an AFO to influence alignment, improve posture, or compensate for a neuromuscular deficiency.

This Evidence Note considered published research only if it described subjects fitted with an AFO and utilized a clinical- or laboratory-based balance measure as an independent variable.

**Balance Theory**

Balance is a complex skill necessary to maintain the body’s center of gravity (COG) within the base of support while stationary (static balance), and to control the center of mass in dynamic situations, such as walking or when subject to a destabilizing event (dynamic balance). Recent theories suggest that to maintain balance, a multi-system approach be used that involves a combination of cognitive, motor, cerebellar, vestibular, and proprioceptive systems. One of the most important biomechanical constraints on balance is the base of support and the ability to move the center of mass with respect to this base of support (limits of stability). Limitations to joint range of motion (ROM), muscle strength, and sensory input can all significantly affect stability limits.

**Summary of the Evidence**

A single systematic review describing the effects of AFOs on balance formed the basis of this Evidence Note. This systematic review was part of the tenth State of the Science Conference of the American Academy of Orthotists and Prosthetists (the Academy), and summarized research from 37 research articles, of which 18 related to sports orthoses and 19 related to ambulatory orthoses.

**Orthoses for Sporting Applications**

The major goal of orthoses designed for sporting applications is to provide mechanical support for the ankle-joint complex. There is also some suggestion that circumferential pressure applied by orthoses can facilitate balance by improving proprioceptive input. The majority of research addressing the influence of sports orthoses on balance utilized either laced-up and/or semi-rigid off-the-shelf designs and these designs seemed to perform similarly.

Studies utilizing able-bodied subjects were most common.
and indicate that sports orthoses are unlikely to compromise balance in this population. A smaller number of studies have been conducted on persons with diagnosed ankle instability.12–16 The results suggest with a moderate level of confidence that sports orthoses can facilitate balance in this cohort. Two papers were identified that specifically addressed the use of an orthosis to facilitate proprioception and subsequently enhance balance.5,9 Unfortunately, study design limitations in both papers preclude any conclusive statements.

**Ambulatory Orthoses**

There is low to moderate evidence suggesting that performance on certain balance-related outcome measures is dependent upon the specific biomechanical design of the AFO. Of particular interest is that use of rigid orthoses tended to result in either no change or in improvement of performance on static balance tests; however, their use was associated with a deterioration in performance under dynamic test conditions for persons with gait abnormalities.17,18 Results from several studies suggest with a high level of confidence that leaf-spring orthoses may have positive effects on balance in adults with stroke-induced hemiplegia.18–21 Results about the use of supramalleolar orthoses suggested with a moderate level of confidence that they can enhance balance for children diagnosed with cerebral palsy.22–24

**General Comments and Future Research**

This Evidence Note focuses solely on studies utilizing outcome measures of balance. No consideration has been given to other variables that may be affected by the use of an AFO (e.g., gait mechanics). Balance is just one factor that should be considered by clinicians when prescribing an AFO, and findings reported in this Evidence Note must be weighed against other potential benefits or disadvantages associated with the use of an orthosis.

Additional research is needed to investigate the relative effects that AFOs have on proprioception, the relationship between proprioception and balance, and the impact of AFO design on balance. It is important to recognize that performance on balance-related outcome measures may be dependent not only on orthotic design but also on the subject group selected for study. To generate appropriate prescription criteria, a wide variety of patient diagnostic groups must be investigated.

**Acknowledgments**

This Evidence Note was compiled by Nerrolyn Ramstrand, PhD, BP&O (Hons), and Simon Ramstrand, MSc, BP&O, and was made possible by the Academy through a grant (Award Number H235K080004) from the U.S. Department of Education. The contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the federal government.

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**References**


# 2011–2012 AAOP Membership Application

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Qualitative Understandings of the Lower Limb in Children with Bilateral Cerebral Palsy

Marty J. Carlson, CPO, FAAOP
Phillip M. Stevens, MEd, CPO, FAAOP

Part 2

Understanding Crouch Deformity

In part 1 of this series (the Academy TODAY, March 11, pg. A-4–A-5), we examined the foot and ankle irregularities most frequently observed in children with bilateral cerebral palsy, attempting to provide a qualitative understanding of how and why these deformities develop and often worsen over time, as well as the principles of their orthotic management. In part 2, we examine the crouch deformity so commonly and readily observed at the knees (Figure 1).

The loss of full knee extension may be the result of several overlapping biomechanical influences. While this article will focus primarily on the events at the knee joint itself, factors both proximal and distal to the joint warrant a brief discussion. Beginning at the foot and ankle, any deviation that compromises the efficiency of the plantarflexors will ultimately weaken the so-called “plantarflexion/knee extension couple,” contributing to knee flexion in stance. In cerebral palsy, these deviations may include weakness, surgical over-lengthening, compromised motor control of the soleus muscle, and what James Gage, MD, has frequently referred to as “lever-arm dysfunction.” The latter refers to rotational deformities of the foot and shank, such as external tibial torsion or a pes valgus foot deformity, which decreases the functional length of the anterior toe-lever in stance, drawing the ground reaction force posteriorly and increasing the likelihood of it passing posterior to the knee. Regardless of the underlying cause, functional compromise to the strength or action of the plantarflexors increases the demands upon the knee extensors, which are themselves often mechanically insufficient.

Though less frequently discussed, there is a second “hip-extension/knee extension couple” which has direct influence on the body’s ability to maintain its upright alignment. The relationship between knee flexion and hip flexion is twofold. First, the hamstrings and rectus femoris are biarticular muscles, crossing both the hip and knee joints in such a way that, with any level of muscle shortening, flexion at one joint will tend to cause flexion of the other. Second, the geometry of an upright stance requires compensatory flexion at the alternate joint segment if flexion is present in the other. Examination should always determine, if possible, which postural deviations are structural and which are functional compensations.

Returning to the knee joint itself, there are some common misconceptions about why many children with cerebral palsy stand and walk with flexed knees. One theory is that it is an
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attempt to lower the center of gravity (COG) to aid balance. However, further consideration renders this theory unlikely. Even 50 degrees of knee flexion will lower the body COG by less than 10 percent.

A second supposition voiced on occasion is that the bent-knee stance results from weak quadriceps and that strengthening exercises for the knee extensors are indicated. This also seems improbable because, as we will discuss, the flexed-knee stance so often assumed in this population requires enhanced knee extensor strength (Figure 4). Thus, low quadriceps strength does not appear to be the problem. (A careful distinction should be drawn between the strength and mechanical efficiency of the quadriceps. The latter does appear to affect the progression of a crouch and will be discussed below.)

We can identify several other biomechanical factors that appear to contribute to the flexed-knee stance. Hamstring tightness and spasticity is almost universally observed in this population. The hamstrings are a large, strong muscle group and usually represent the primary resistance to full knee extension. The graph in Figure 2 qualitatively illustrates the rapid increase in the resistance that a hypothetical patient might experience as full knee extension is approached. Importantly, while the generalities of this graph will remain consistent from patient to patient within this population, the exact position and slope of the knee extension resistance moment will vary according to such things as structural contracture and level of spasticity.

A second factor in considering the knee extension moments acting within this population is the effect of gravitational forces across the knee joint. Straightforward mechanical analysis can relate a given knee flexion angle to the associated flexion moment at the knee (Figure 3). Increases in knee flexion angles will increase the radius of the external knee flexion torque due to gravity. For example, within a simple modeling analysis, when a 35kg subject stands with knees flexed 50 degrees, his quadriceps must generate a moment of about 3 kilograms per cubic meter (kgm) just to offset the collapsing effect of gravity (Figure 4). Alternatively, if the subject stands in well-aligned, full knee extension, virtually no effort is needed against gravity (Figure 4).

The graph in Figure 5 illustrates the combined effects of gravity and tight hamstrings as a function of knee extension, with the dashed line representing the summation of the two factors. The left side of the graph represents the absence of crouch. The extreme right side of the graph represents a deep crouch. Following the dashed line from the left, we see that as the subject straightens from the deep crouch, the necessary quadriceps effort decreases as the knee centers move closer to the weight line and the radius of the flexion moment, due to gravity, decreases. However, at a point that will vary from patient to patient according to the structural length and functional spasticity of the hamstrings, this muscle group will begin to significantly resist knee extension. Assuming some level of contracture, this resistance may increase quite quickly as the knees approach full extension.
By examining the dashed line in this modeling exercise, it becomes clear that the hypothetical subject would likely choose to stand with his knee flexed about 40 degrees, as this represents the minimum available extension force requirement. Conversely, standing with either more or less knee flexion would require even greater quadriceps effort. Again, note that this analysis is qualitative. Each child will present with unique muscle tone and contracture factors and will find his own particular stance or posture depending on those factors.

As the months and years progress, the extraordinary tension of the quadriceps will stretch and elongate the patello-tibial ligament as it binds the distal aspect of the patella to the tibial tubercle. As the child grows, this elongation leads to the ultimate development of patella alta, or an abnormally high patella in relation to the femur. The photograph in Figure 6 was taken to document a case of severe foot deformity of the type described in an earlier article (The Academy TODAY, 2011;7(2):A4–5). However, notice the boy’s knees. The patellae are riding entirely above the femoral epicondyles to the extent that the profile of the femoral condyles and the intercondylar notches are clearly seen below the lower border of the patellae. In this instance, the patello-tibial ligament has been stretched to perhaps twice the normal length.

The change in the position of the patella profoundly alters the mechanics and effectiveness of the quadriceps. It does so in several compounding ways:

1. As the patellar ligament lengthens, the resting length of the quadriceps muscle belly is reduced; the muscle is thus “weakened,” similar to what happens in a surgical tendon-lengthening procedure.
2. As the patella moves above the femoral condyles, the patellar ligament slips into a position in the femoral intercondylar groove where it has less mechanical advantage to create an extension moment.
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Figures 7 and 8 compare the normal alignment with the patella alta configuration. Note that in the patella alta condition, the tendon, lying deep within the intercondylar groove, passes closer to the center of rotation. Thus the extension moment produced by any amount of quadriceps pull is reduced. This effect is greater as full knee extension is approached because the patella is then entirely above the condyles.

3. Because of the geometry and mechanics of the knee, as the patellar ligament lengthens, more and more of the quadriceps tension is transferred to the patellar retinaculum. Retinaculum tension is much less effective in extending the knees because these structures pass closer to the center of motion, as seen in Figure 8. Because of knee kinematics, this transfer of tension from the patellar ligament to the retinaculum increases as the knee approaches full extension (Figure 9). Note that both the loss of mechanical advantage and the tension transfer to the retinaculum are increasingly occurring as the knee approaches full extension.

4. A fourth factor is what happens to the force vectors of the vastus medialis and vastus lateralis as the patello-tibial ligament lengthens. As the patella rises, the forces exerted by the two vastii muscles become more and more oppositional rather than pulling mostly in the same direction (Figure 10).

Thus, while crouch gait is unlikely to be the result of quadriceps weakness, it is almost certainly affected by the progressive mechanical insufficiency of an often deteriorating knee extensor mechanism.

With respect to the provision of orthotic care, clinicians should appreciate the many factors that can contribute to producing the crouching phenomenon and that its resolution is beyond simple modalities of stretching and strengthening the hamstrings and quadriceps, respectively. Orthoses may be prescribed and designed to assist the integrity of the plantarflexor/knee extensors couple during stance or provide a nocturnal stretch to tightened hamstrings. However, they represent only part of the solution to this commonly encountered, complex presentation. The profound ways in which development at the knee is affected by unresolved problems at neighboring joints underscores the value of an early, aggressive, and coordinated approach.

Editor’s note: Some images appearing in this publication were previously submitted and published in Orthopadie Technik. With permission, they appear here with an additional, more current perspective.

References
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