Celebrating 43 Years of Excellence

PROSTHETIC & ORTHOTIC UPDATE

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# Is He Too Fast for the Olympics?

It is the way of the sporting world that physically challenged athletes compete with and against other physically challenged athletes. That approach "levels the playing field," you see, preventing "disabled" men and women from being placed at unfair disadvantage in contests with "whole" or able-bodied competitors. Thus we have the Paralympics, O&P Extremity Games, and various other events created especially for amputees and other "less-than-fully-capable" contenders.

***Oscar Pistorius's speed has launched Olympic-size controversy.***

*Photos courtesy Össur Americas*

Given the capabilities of prosthetic componentry throughout history, that approach has made perfect sense. There's no way a lower- or upper-extremity amputee wearing even the best available prosthetic limb would have a chance against an otherwise-comparable "fully equipped" competitor. No way!

Or such was the conventional wisdom before Oscar Pistorius came along. Now, to borrow another sports cliche, It's a whole new ball game.

Pistorius, 21, is the South African sprinter who runs with, and away from, some of the world's elite runners despite the minor inconvenience of being a bilateral lower-limb amputee. Running on Cheetah carbon-fibre prosthetic feet, he has toppled Paralympic records in various dash events and has announced his hope of moving up to better competition by running this year's Beijing Olympics.

Ah, ah, ah, ah.... not so fast, young man. Never a concern before, the technological advances of prosthetic science in recent years now apparently constitute a threat to the running establishment. Mr. Pistorius's Cheetahs are nothing but cheaters, opponents complain, springing him to an unfair advantage.

In early 2008, the International Association of Athletics Federations (IAAF), track and field's governing body, ruled that his prostheses are in fact "technical aids" that give Pistorius a clear advantage over able-bodied runners and therefore he is ineligible to compete in the Olympics. Pistorius has appealed the ruling to the Court of Arbitration for Sport, the results of which were unannounced as this newsletter went to press.

It is not our purpose to take a position on whether Oscar Pistorius should be allowed to run in the Olympics but rather to note the irony of prosthetic legs now being considered too good a replacement for lost human limbs. (Pistorius, incidentally, was born without fibulas and underwent transtibial amputations at age 11 months.)

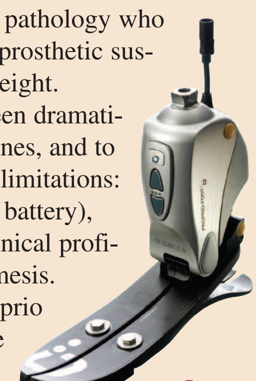
Whether or not he ultimately runs in the Olympics, Oscar Pistorius's success marks a decisive turning point in the development of prosthetic limbs. The IAAF tests that preceded that body's decision found that Pistorius's prostheses enabled him to run at the same speed as able-bodied sprinters with about 25 percent less energy expenditure and that the returned energy they provided was close to three times higher than that of the human ankle joint.

We have not yet reached the point that a prosthetic limb can outperform the human limb...but it's noteworthy that some important people think so.

Nobbe Orthopedics is pleased to serve as a Beta test site for the Össur Proprio Foot. In our experience with this new, powered, ankle-foot system, we have come to appreciate its ability to help a distinct patient population—moderate activity-unrestricted community ambulators with either contralateral lower-extremity involvement and/or back pathology who nonetheless have the strength and secure prosthetic suspension to manage the Proprio's added weight.

For the appropriate patient, we have seen dramatically easier negotiation of ramps and inclines, and to a lesser extent, stairs. We also have noted limitations: added weight and bulk (largely due to the battery), noise in quiet environments, required technical proficiency for operation and problematic cosmesis.

As with most new technology, the Proprio Foot is far from a perfect solution, but we are finding it is a good step in the right direction, and we know it will get better.



*Courtesy, Össur Americas*

# Prosthetic Feet Hitting New Strides of Performance, Patient Acceptance

Courtesy Otto Bock Health Care

Choosing a foot component for a new prosthetic limb these days is no easy business. Once a simple choice among a handful of distinctly different designs, an informed selection of a specific ankle-foot mechanism today has become a complex matter requiring knowledge of, and experience with, a steadily growing spectrum now numbering more than 100 foot designs.

**Prosthetics Today**

Without question, "innovation motivation" has taken hold in the once-staid prosthetics specialty as well-heeled U.S. and global manufacturers strive to "out-tech" each other to create the latest, greatest prosthetic leg. When that technology can be translated optimally to a particular individual's anatomy, lifestyle and personal aspirations, there's no telling how far the process will take us.

Nevertheless, selecting the "best" foot from the expanding list of contenders can be quite a challenge as time-honored favorites are regularly surpassed in technology, performance, and patient acceptance. It is the prosthetist's role to remain current on the latest proven products and thereby help the prescribing physician, patient, caregivers, and others involved in the rehabilitation effort understand the benefits and drawbacks of the various feet under consideration.

*SACH foot (K1-2)*
*Courtesy Ohio Willow Wood*

The ankle-foot component is a critical determinant of prosthetic success. The closer it matches the abilities, environment and activity desires of the amputee, the better the outcome.

*Single-Axis Foot (K1-2)*
*Courtesy Ohio Willow Wood*

The Health Care Financing Administration's system of functional levels governing Medicare reimbursement for lower-limb prosthetics (see page 3) provides a convenient framework for categorizing the various ankle-foot options by performance and patient type.

### Level 1 - Household Ambulators

Amputees in this category tend to be older patients who have undergone amputation due to vascular insufficiency. They generally require safe, basic function and light weight for moving relatively short distances. The **SACH** (solid ankle, cushion heel) **foot** is generally the foot of choice for this type of patient, although a single-axis foot may be appropriate for higher-level amputees.

## Note to Our Readers

*Mention of specific products in our newsletter neither constitutes endorsement nor implies that we will recommend selection of those particular products for use with any particular patient or application. We offer this information to enhance professional and individual understanding of the orthotic and prosthetic disciplines and the experience and capabilities of our practice.*

*We gratefully acknowledge the assistance of the following resources used in compiling this issue:*

*BioQuest Prosthetics, LLC. • College Park Industries*
*Freedom Innovations • Ohio Willow Wood • Össur*
*Otto Bock Health Care • Seattle Systems*

The SACH foot simulates plantarflexion at heel strike by compression of an elastic heel wedge and provides forefoot dorsiflexion by means of a flexible toe section. The SACH foot's simple construction (no moving parts), light weight, low cost and minimal maintenance requirement make it the common choice for Level 1 patients; enhanced versions are frequently selected for Level 2, and occasionally even Level 3 patients as well. Reflecting its simplicity and comparative low cost, the SACH foot is frequently selected for preparatory (temporary) prostheses, regardless of functional level.

*Accent Foot (K3)*
*Courtesy College Park Industries*

Note: The SACH foot generally offers less knee stability than articulating foot designs. Consequently, ankle-foot components with moving joints are generally preferred for above-knee applications.

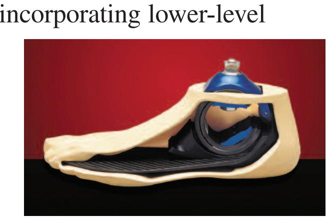
The **single-axis foot**, the predominant prosthetic foot design until the early 1960s, was originally developed during the Civil War. This most basic of the articulating foot designs provides plantarflexion-dorsiflexion movement about an "ankle" axis, limited and cushioned by bumpers. Single-axis feet are typically lightweight, low-cost and light-duty, although certain models incorporating dynamic response characteristics are rated as high as Functional Level 3. Because articulating feet increase knee stability in early stance phase, they are often preferred for above-knee amputation levels.

*Seattle Lightfoot (K3)*
*Courtesy Seattle Systems*

### Level 2 - Limited Community Ambulators

Amputees whose functional potential fits in this category can benefit from more durable SACH foot models, non-articulating elastic keel feet, certain multiaxial designs, and feet incorporating lower-level energy-storing characteristics.

Non-articulating **elastic keel feet** provide function similar to a SACH foot but are a bit more flexible, allowing the forefoot to adjust to varied walking conditions and conform to uneven surfaces.



*C-Walk Foot (K3)*
*Courtesy Otto Bock Health Care*

**Multiaxial ankles** are well-suited to community ambulators in that they provide triplanar accommodation of uneven terrain—inversion-eversion, internal and external transverse rotation, and dorsiflexion-plantarflexion. The multiaxial mechanism may be a distinct ankle component mated to a separate prosthetic foot or an integral part of the foot.

Originally suited primarily for only the strongest, most active patients, multiaxial components have evolved into less-complex and lighter designs that are now appropriate for less-capable individuals as well. Multiaxial feet are particularly appreciated by amputees who enjoy outdoor activities, notably hikers and golfers. They also lend themselves well to the needs of bilateral amputees.

### Level 3 - Active Community Ambulators

Amputees within this classification have access to many advanced design features, which typically incorporate dynamic assist at toe-off, helping propel the leg into swing phase and reducing energy expenditure.

*Trailblazer (K3- 4)*
*Courtesy Ohio Willow Wood*

These energy-storing-and-release or **dynamic response feet** address a frequent complaint of lower-limb prosthesis-wearers: the "dead leg" feeling experienced with each toe-off as residual limb musculature must provide total propulsion of the prosthesis. In a dynamic response foot, the flexible keel functions as a spring, which deforms during weight-bearing, storing energy, then releases that energy during late-stance phase, providing forward propulsion.

Early dynamic response feet were created mostly for amputee athletes, but steady improvements in design, weight reduction, reliability and cost have brought these components within the realm of moderately active, "everyday" amputees.

Most of the early dynamic response models lacked an ankle component; however, improvements in multiaxial design have made systems combining articulating and dynamic response characteristics not only possible but practical. These advanced designs are providing performance, comfort and stability never before available to most patients.

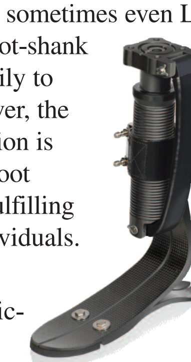
*LuXon Max Low Profile (K3-4)*
*Courtesy Otto Bock Health Care*

### Level 4 - High Activity — Child, Active Adult, Athlete

True Level 4 applications are typically high-tech, high-impact and high cost. They are also the proving ground where the everyday systems of the future are developed. Relatively few amputees will qualify for reimbursement of ankle-foot components in this category, but the principles and features incorporated into these highly sophisticated systems have a way of appearing in feet appropriate for patients of lower functional level in future years.

*Renegade (K3-4)*
*Courtesy Freedom Innovations*

The first lightweight, high-strength Flex-Foot designs, for example, were built to serve the needs of premier amputee athletes. Once proven, those advanced concepts of the 1980s were subsequently refined and incorporated into products more suited to the needs of Level 3 and sometimes even Level 2 patients. The classic Flex-Foot J-shaped foot-shank composite is still provided primarily to younger, vigorous patients; however, the underlying carbon-fibre construction is being built into more-traditional foot models that can provide a more fulfilling lifestyle for older, less-active individuals.



*ReFlex VSP (K3-4)*
*Courtesy Össur Americas*

*Silhouette (K3-4)*
*Courtesy Freedom Innovations*

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So how do we arrive at a particular foot recommendation for a given patient? We start with a thorough assessment of the patient's age, physical condition including amputation level, mental capabilities, lifestyle including vocational requirements, and the desires and expectations of the patient and his or her family. We assess ambulation potential, including stability and balance, predicted cadence, weight and overall fitness, then factor in financial resources and family support.

Foot selection typically entails tradeoffs involving performance, durability, weight and cost. While active patients and amputee athletes garner the lion's share of the media and marketing attention, the far greater numbers of lower-limb amputees occupy the opposite end of the ability spectrum: typically older, dysvascular people who have neither the energy nor the desire to walk more than a block or two. For these patients low weight, and often low cost, become overriding factors.

*TruStep (K3-4)*
*Courtesy College Park Industries*

Reimbursement, by private insurance and Medicare, often limits the range of choices. The concept is good for limiting fraud and abuse; however, prosthetists in some cases are discouraged from providing the foot they feel will be of most benefit to a patient because it will not qualify for reimbursement given the patient's functional level.

Our practice is prepared to work with you in recommending and providing the most appropriate prosthetic components for each patient we serve, reflecting both physical and fiscal realities.

## Predicting Functional Outcomes

The U.S. Health Care Financing Administration (HCFA) has established a patient's functional potential as the primary criterion for determining whether a particular lower-limb prosthetic component will be approved for Medicare reimbursement.

An amputee's predicted functional level, sometimes known as K level, is generally determined by the referring physician and prosthetist, taking into account (1) the patient's history and (2) current status, including condition of the residual limb and other medical problems; and (3) his or her desire to ambulate.

**Level 1:** Amputee has the ability or potential to use a prosthesis for transfers on level surfaces at a fixed cadence. Typical of the limited household ambulator.

**Level 2:** Amputee has the ability or potential for ambulation with the ability to traverse low-level environmental barriers, such as curbs, stairs and uneven surfaces. Typical of the unlimited household and limited community ambulator.

**Level 3:** Amputee has the ability or potential for ambulation with variable cadence. Typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic or exercise activity that demands prosthetic utilization beyond simple locomotion.

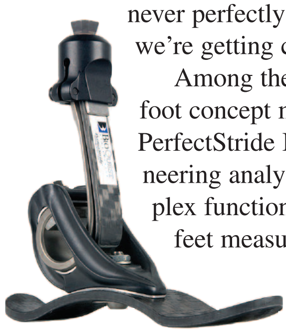
**Level 4:** Amputee has the ability or potential for prosthetic ambulation that exceeds basic ambulation skills, exhibiting high impact, stress or energy levels. Typical of the prosthetic demands of the child, active adult or athlete.

# Replicating Functions of the Human Foot

**What's New**

The progression of prosthetic foot design throughout history has pursued one overarching objective: To replicate as closely as possible the biomechanical functions of the human foot. With a normal foot incorporating 26 bones, 33 joints and more than 100 muscles, tendons and ligaments, that would seem a nearly impossible task.

Nevertheless, as illustrated in the inside pages of this newsletter, we've have seen great advances toward that goal in recent years...and the innovation push continues. We'll likely never perfectly replace the marvelous natural foot, but we're getting considerably closer.



*PerfectStride II*

*Courtesy BioQuest Prosthetics*

Among the latest advances is an intriguing new foot concept more than five years in the making. The PerfectStride II™ was engineered around detailed engineering analysis of how the human below-knee complex functions during gait and how existing prosthetic feet measure up in replacing that function.

The new design consists of a titanium calf shank and ankle coil coupled to a carbon graphite foot keel, which interact to deliver triplanar reaction to gait forces much as the human foot does. At heel strike, these components combine to absorb compression shock and store momentum load, which they sequentially return during foot flat, late stance and toe off, propelling the prosthetic limb forward and upward.

The foot's creators commissioned gait studies at Stanford University, the University of Southern California and Rancho Los Amigos National Rehabilitation Center, which document that, as compared with other leading prosthetic feet, the PerfectStride II generates more forward momentum, lowers oxygen consumption, enhances gait symmetry and velocity, and reduces socket forces on the residual limb. If these findings are borne out for significant numbers of amputees, this foot could go down as a milestone technological advance in prosthetic design.

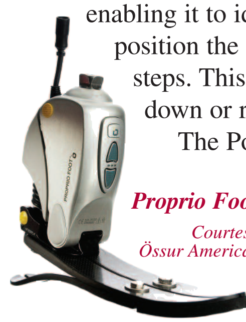
*Courtesy BioQuest Prosthetics*

The PerfectStride II's relatively tall build height makes it best-suited for patients with mid-transtibial deficiencies and higher; thus, most lower-extremity amputees may benefit from this design including transfemoral, knee and hip disarticulation, and hemipelvectomy patients. The foot is rated for patients at Functional Levels K3 and K4.

## Powered Foot Components

It is somewhat surprising that with powered hand, wrist and elbow components available for upper-limb prostheses for many years, similar technology did not enter the mainstream of lower-limb prosthetics until just 2007 with the introduction of the Proprio™ Foot. Apparently it's now an idea whose time has come, for another powered foot system is on the near horizon.

The Proprio Foot was named for its ability to mimic the body's ability to "sense" the foot's location in space — i.e. proprioception— enabling it to identify inclines and stairs after one step, then position the powered ankle appropriately for succeeding steps. This active ankle motion also allows wearers to sit down or rise from a chair more easily.



*Proprio Foot*

*Courtesy Össur Americas*

The PowerFoot One™, an actively powered prosthetic ankle based on research at MIT's Media Lab and developed with partial funding from the Veteran's Administration and U.S. Army, will make its debut in mid-2008. We will address this new foot in a future issue.

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