

Prosthetic Feet Classification & Overview



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"Demonstration Project on Prosthetics & Orthotics"

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Objectives

Upon completion of this unit, the student will:

- Demonstrate understanding of Medicare's Functional Modifier classification system
- Apply K scores to patient scenarios
- Recall the six categories of prosthetic feet
- Be able to describe popular examples of prosthetic feet in a given foot category
- Recall benefits and drawbacks associated with prosthetic feet from the six categories
- Be able to select an appropriate prosthetic foot based on a case scenario

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Medicare Functional Modifiers


The "K" Scale:

K Level	Functional Description	Prosthetic Feet	Prosthetic Knees
K0	Non-ambulatory. Not a prosthetic candidate.	None	None
K1	Limited and unlimited household ambulation. Level surfaces. Fixed cadence. Transfers and therapeutic use.	Basic Feet: External Keel, SACH, Single Axis	Basic knees
K2	Limited community ambulation. Able to traverse low-level environmental barriers (curbs, ramps, stairs, uneven surfaces).	Multi-axial feet, Flexible Keel feet, Axial rotation (ankle) unit	
K3	Community ambulation. Variable cadence gait (or potential). Most environmental barriers.	Dynamic response feet	Fluid & Pneumatic knees
K4	Children. Those with Bilateral involvement. Active adult. Athletes. Exceeds basic use.	Any	Any


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Who are they?


K1





K2




K3







K4



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Classes of Feet

1. SACH feet (solid ankle cushioned heel)
2. Single Axis feet
3. Multi-axial feet
4. Dynamic response/ Energy storing feet
5. Multi-axial + Dynamic response feet
6. Adjustable heel height feet

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SACH (solid ankle cushioned heel)

 <small>Smith-Global SACH Foot for K1 Level Non-ambulators</small>	 <small>Kingsley Symes SACH Foot</small>	 <small>Ohio Willow Wood SACH Foot</small>
 <small>Kingsley SACH Foot</small>	 <small>Ohio Willow Wood SACH Foot w/ pyramid</small>	 <small>Ohio Willow Wood P-Pod (pediatric) SACH Foot</small>
 <small>Kingsley Continental SACH Foot (1" heel)</small>	 <small>Kingsley Hi-Style SACH Foot (3/4" heel)</small>	 <small>Kingsley Wayfarer SACH Foot (flat w/ split toe)</small>

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SACH (solid ankle cushioned heel)

Benefits

- Several heel heights
- Several weight categories
- Several activity level categories
- Several manufacturers
- Syme's option
- Durable- low maintenance
- Good choice for pediatrics
- Easy to replace
- Endo or Exoskeletal
- Inexpensive Option for all K levels



Kingsley SACH Foot



Kingsley Juvenile SACH Foot



Kingsley Cowboy Hi-Heel SACH Foot (1-3/8" heel, smooth toes)

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SACH (solid ankle cushioned heel)

Drawbacks

- Not for use if active keel is needed
- Poor multi-axial abilities
- Poor choice if knee stability is questionable
- Poor shock attenuation



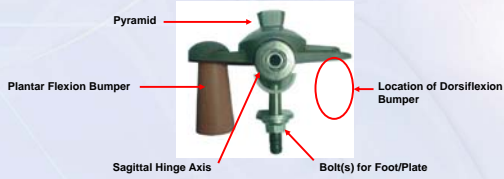
Foot Bolt and SACH foot adapter. Also works on Seattle Feet.

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Single Axis feet



Ohio Willow Wood



Components of Single Axis foot

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Single Axis Feet

Benefits

- Adjusts joint angle to accommodate uneven terrain (sagittal only)
- Plantar and Dorsiflexion bumpers are replaceable with more or less compliant bumpers
- Relatively inexpensive
- Indicated when knee stability is an issue (TTA or TFA)
- Option for all K levels

Drawbacks

- Increased maintenance associated with moving parts
- Difficulty cosmetically finishing due to moving parts
- Contraindicated if knee is stable
- Contraindicated if multi-axial function is needed
- Contraindicated if dynamic response is needed

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Multi-Axial Feet

A foot or foot-ankle system that moves or articulates in more than one plane.

- Inversion,
- Eversion,
- Plantar Flexion
- Dorsi Flexion
- Transverse Rotation

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Multi-Axial Feet

Examples:

- Greissinger Plus™ from Otto Bock Health Care®
 - Endolite™ Multiflex Foot & Ankle®
 - Ohio Willow Wood® Earthwalk2™
- ** the Multiflex and Earthwalk2 systems include separate ankle units**



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Multi-Axial Feet

Benefits

- For use with K2 ambulators & above
- Accommodates to uneven ground
- Variety

Drawbacks

- Offers little energy for toe off
- Increased cost
- Increased maintenance
- Each has separate procedure for cosmetic finishing
- Accommodation period and training

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Dynamic Response/Energy Storing Feet

Examples

- *Seattle Lite™* by Seattle Limb Systems®
- *Pathfinder™* by Ohio Willow Wood®
- *Axtion™* by Otto Bock Healthcare®



Pathfinder from Ohio Willow Wood



Axtion from Otto Bock Healthcare

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Dynamic Response/Energy Storing Feet

Benefits

- Returns stored energy, which aids in propelling foot forward at toe off
- For active ambulators (K3 and above)
- Some designs offer limited multi-axial accommodation (not technically considered multi-axial)
- Variety



1D35 Dynamic Motion Foot from Otto Bock Healthcare

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Dynamic Response/Energy Storing Feet

Drawbacks

- Typically expensive
- Varied cosmetic finishing procedures
- Moving parts may mean increased maintenance
- Accommodation period

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Multi-Axial + Dynamic Response Feet

- Combines aspects of both features
- Closest functional replacement of anatomy
- Represents "state of the art" for prosthetic feet



ADP2 (Advantage Dynamic Pylon)
from Otto Bock Healthcare

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Multi-Axial + Dynamic Response Feet

Examples:

- Ossur® Flex Feet® Line
 - Vari-Flex®
 - Ceterus®
 - Talux®
 - Axia™



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Multi-Axial + Dynamic Response Feet

Examples:

- Springlite™ Line and Advantage Dynamic Pylon (DP) 2 by Otto Bock® Healthcare
 - LuXon™ Max Dynamic Pylon (DP)
 - The Springlite™ II



ADP2 (Advantage Dynamic Pylon)
from Otto Bock Healthcare

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Multi-Axial + Dynamic Response Feet

Benefits

- Variety
- Excellent functional options
- Solution for high-level patient/clients

Drawbacks

- Expensive
- Not for lower level ambulators
- Accommodation period

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Adjustable Heel Height Feet

- May have preset or infinite adjustability within a given ROM
- ROM ≈ 30° (or ≈ 2 inches of heel height)
- Typically Medial push button release

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Adjustable Heel Height Feet

Examples:

- *Elation™* by Ossur®
- *Runway™* by Freedom Innovations®



Elation by Ossur

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Adjustable Heel Height Feet

Benefits

- Adjusts heel height for different footwear
- Option for dynamic response or flexible keel



Runway by Freedom Innovations



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Adjustable Heel Height Feet

Drawbacks

- Not eligible for Medicare reimbursement
- Increased moving parts; Increased maintenance
- May require two different density foams to cosmetically finish
- Can be heavier than other feet
- Expensive



Elation by Ossur

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Additional Components

- Rotators
- Torsion Adapters
- Ankle Units

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Rotators

- Allow Cross leg sitting
- Donning shoes
- Used typically with trans-femoral and more proximal level amputees



Rotation Adapter 4R57 from Otto Bock Healthcare



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Torsion adapters

- Used at any level, build height permitting when transverse forces require attenuation
- May be installed proximal or distal to anatomic or prosthetic knee
- Variety of manufacturers
- Good for sand and mud (compliant surfaces)
- Good to decrease interface to skin friction in aggressive ambulators



Torsion Adapters 4R85 & 86 from Otto Bock Healthcare



Delta Twist 4R120 from Otto Bock Healthcare



Total Shock from Ossur



Dura shockTorsion Adapters from Fillauer

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Ankle Units

- Add degrees of freedom to non-multiaxial feet
- May be for daily ambulation
- May be application specific



Endolite ankle units



Arthroglide ankle from Seattle limb systems



Rampro ankle unit for swimming



Earthwalk2 foot/ankle system

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Other Classifications

- Vertical Shock
- Flexible Keel
- Ultra Light
- Heavy Duty

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Vertical Shock

- Compressive device
- Ideally adjusted to be equal height during quiet standing
- May be integrated into the foot
- May be extra componentry



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Flexible Keel

- More advanced than a SACH but
- Does not return energy like a dynamic response foot
- Too much action for K1 level ambulators but insufficient for K3 level ambulators
- May or may not be multiaxial; may include an ankle



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Ultra Light

- Sufficient support for
- therapy,
 - transfers and
 - very limited ambulation
 - e.g. household ambulation
 - Minimal weight/mass



The Dycor STM (soft tissue management) foot is for K1&2 level ambulators. The Dycor foot line has higher function feet and all are extremely light weight.

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Heavy Duty

- Required with high mass
- May be body mass or
 - Body mass plus external load
 - e.g. lifting for occupational requirement
 - Most components cut off between 200 and 275lbs
 - Above manufacturer's recommended weight restrictions, custom feet may be available



Magnum HD Foot



Magnum foot and system from Ohio Willow Wood. Rated up to 350 lbs.

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Running Feet

- No Heel
- Radical Alignment and set up
- Cannot wear a shoe
 - Traction considerations
- Versions available for distance running or sprinting

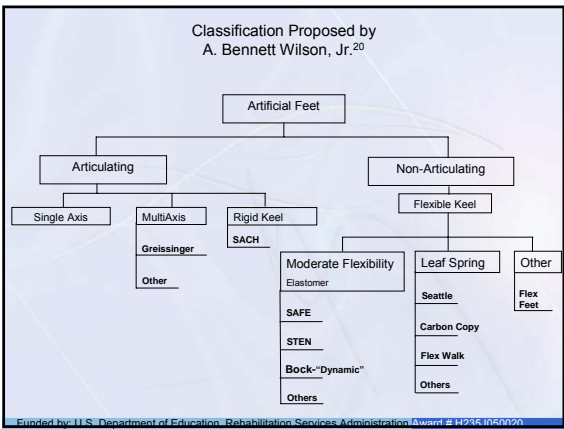


Ossur Flex-Run



Otto Bock Sprinter

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References

1. American Academy of Orthotists and Prosthetists. Prosthetic Foot/Ankle Mechanisms. Official Findings of the Consensus Conference. J Prosthet Orthot(S) 17(4), Oct 2005.
2. Nassan S. The latest designs in prosthetic feet. Phys Med Rehabil Clin N Am. 2000 Aug;11(3):609-25.
3. Culham ET, Peat M, Newell E. Analysis of gait following below-knee amputation: A comparison of the SACH and single axis foot. Physiother Can. 36:237-242,1984.
4. Brouwer BJ, Allard P, Labelle H. Running patterns of juveniles wearing SACH and single axis foot components. Arch Phys Med Rehabil. 70:128-134,1989.
5. Burgess EM, et al. The Seattle prosthetic foot-A design for active sports: Preliminary studies. J Prosthet Orthot 37:25-31, 1983.
6. Czerniecki JM, Gitter A. Impact of energy storing prosthetic feet on below knee amputation gait (abstract). Arch Phys Med Rehabil 71, 1990.
7. Edelstein JE. Prosthetic feet state of the art. Phys Ther 68:1874-81, 1988.
8. Macfarlane PA, et al: Gait comparisons for below knee amputees using a flex foot versus a conventional prosthetic foot. J Prosthet Orthot 3:150-61, 1991.

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References

9. Wirta RW et al: Effect on gait using various prosthetic ankle foot devices. J Rehabil Res Dev 28:13-24, 1991.
10. Doane N, Holt LE. A comparison of the SACH and single axis foot in the gait of unilateral transtibial amputees. Prosth Orth Int 7:33-36, 1983.
11. Lehmann JF, Price R, Boswell-Bessette S et al. Comprehensive analysis of dynamic elastic response feet: Seattle ankle/lite foot versus SACH foot. Arch Phys Med Rehabil. 1993; 74:853-61.
12. Macfarlane PA, Nielsen DH, Shurr DG, Meier K. Gait comparisons for below knee amputees using a flex foot versus a conventional prosthetic foot. J Prosthet Orthot. 1991; 3(4):150-61.
13. Skinner HB et al. Static load response of the heels of SACH feet. Orthopedics. Feb 1985; 8(2):225-8.
14. Torburn L, Perry J, Ayaapa E, Shanfield SL. Below knee amputee gait with dynamic elastic response prosthetic feet: A pilot study. J Rehab Res Dev. 1990; 27: 369-84.
15. Wagner J, Supan T, Sienko S, Barth D. Motion analysis of SACH vs Flex foot in moderately active transtibial amputees. Clin Prosth Orth. 1987; 11(1):55-62.

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References

16. May B. Amputations and Prosthetics. A Case Study Approach. 2nd ed. F.A. Davis. ©2002.
17. Seymour R. Prosthetics and Orthotics. Lower Limb and Spinal. Lippincott Williams and Wilkins. ©2002. ISBN 0-7817-2854-1
18. Shurr DG, Michael JW. Prosthetics and Orthotics. 2nd ed. Pearson Education, Inc. ©2002. ISBN 0-8385-8133-1
19. Lusardi M & Nielsen C. Orthotics and Prosthetics in Rehabilitation. Butterworth-Heinemann. ©2002. ISBN: 0-7506-9807-1.
20. Prosthetics-Orthotics Center. Northwestern University Medical School. Course Manual for Prosthetics 621: Transtibial Prosthetics for Prosthetists. Chicago, IL. 09/2003
21. Wilson AB. A Primer on Limb Prosthetics. Charles C Thomas Publisher LTD. ©1998.
22. HCFA Common Procedure Coding System HCPCS 2001. Washington (DC): US Government Printing Office; 2001. ch 5.3.
23. Ossur Prosthetics Product Catalog 2005. Ossur hf.
24. Otto Bock Health Care. Orthotic & Prosthetic U.S. and Canada 2003 Catalog. © Otto Bock 2003.

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References

25. www.ossur.com
26. www.ottobockus.com
27. <http://www.freedom-innovations.com/>
28. <http://www.endolite.com/>
29. <http://www.rampro.net/>
30. <http://www.seattlesystems.com/>
31. <http://www.college-park.com/>
32. <http://www.smith-global.com/pdfs/Feet2005.pdf>

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