Shoe Wear Recommendations for the Older Adult

Michael T. Gross, PT, PhD, FAPTA

Overview
- Making recommendations relative to comfortable fit or addressing clinical issue.
- 58% ED physicians, hospital discharge planners, HHA nurses, & primary care physicians provided referral or provided intervention for foot or footwear problems (Fortinsky et al, 2008)

Overview
Possible Barriers to Referral or Intervention
- Patient willingness to comply
- Financial resources
- Availability of services
- Knowledge on the part of the practitioner

Overview
Purpose
- Poor balance
- Slipping
- Risk for falling
- Shock absorption
- Knee osteoarthrosis
- Hallux rigidus
- General fit requirements

Poor Balance
Heel Lift
- Heel lift of 32 mm (1.3 in) resulted in increased postural sway for older women, and more conservative gait pattern including increased double support time compared with standard 14 mm (0.55 in) heel (Menant et al, 2008 & 2009)
- Decreased forward functional reach and walking velocity (Arnadottir & Mercer, 2000)
- Heel lift shifts COM anteriorly, thereby decreasing ability to shift COM anteriorly

Poor Balance
Heel Lift
Heeled shoe decreases the anterior-posterior base of support.
Poor Balance
Heel Lift
- Caveat to wearing shoes with reduced heel lift - ankle joint equinas
- The story of "Miss Dorothy" and her ruby red high heeled shoes
- Tight triceps surae requires heel lift to decrease risk of falling backwards
- Goldie Locks and porridge preference.
- Experiment with heel lift inside shoe.

Poor Balance
Stiffness of Sole Material
- Shoes with sole material that is too soft and lacks too little stiffness (Shore A-25) decreased medial-lateral stability compared with shoes with more neutral stiffness (Shore A-40) - Menant et al, 2008
- Soft sole material also results in detrimental effects on gait stability - Menant et al, 2008 & 2009
- These materials produce an unstable support surface for weight bearing.

Poor Balance
Width of Sole Material
- More stable gait characteristics - Menant et al, 2009
- Reduced postural sway, improved limits of balance, and greater stability than shoes with lower collars - Lord et al, 1999
- These shoes may assist ankle musculature with maintaining A-P & M-L stability for proximal foot and ankle joints.

Poor Balance
Height of Heel Collar
- Albright and Woodhull-Smith (2009) demonstrated increased A-P instability when subjects wore the rocker bottom sole and an anterior perturbation was imposed.
- This shoe provides limited base of support in both the anterior and posterior directions.

Poor Balance
Oh, The Rocker Bottom Shoe! I Must Have Them!
- Albright and Woodhull-Smith (2009) demonstrated increased A-P instability when subjects wore the rocker bottom sole and an anterior perturbation was imposed.
- This shoe provides limited base of support in both the anterior and posterior directions.
Poor Balance

The Rocker Bottom Shoe

- This shoe only has the anterior portion of the rocker bottom configuration
- Also resulted in increased A-P instability with anterior perturbation Albright & Woodhull-Smith, 2009.
- Desirable for the painful condition of hallux rigidus, however.

Poor Balance

Summary

- Avoid elevated heel heights unless patient has ankle joint equinæ
- Avoid excessively soft sole material
- Avoid rocker bottom soles
- Select shoes with wider sole materials
- Select shoes with more superior collar for upper materials
- Simply wear shoes rather than go bare foot Horgan et al, 2009

Poor Balance

Slipping

Hardness of Sole Material

- Subjects who wore shoes with harder sole material (Shore 54D) were more likely to slip than when they wore softer sole shoes (Shore 75A). Tsai & Powers, 2008; Chaffin et al, 1992
- Shore® (Durometer) Test- penetration depth of an indenter rod to assess hardness.
- Test shoes for hardness by pushing vigorously with your thumb or small diameter object such as ball point pen with tip retracted.

Slipping

Sole Tread

- Wider and deeper tread grooves in the sole material provide greater coefficients of friction against slipping. Li et al, 2004 & 2006
- \( F_{\text{max}} = \mu \cdot N \)
- "Better Drainage"
Slipping
Colder Climates & Roughness of Sole

- Gao et al (2004) very interested in this issue since many older countrymen in Sweden are injured each year slipping on icy ground surfaces.
- Shoes with rougher sole material (versus very smooth) are associated with greater coefficients of friction and reduced risk of slipping.

Slipping
Icy Ground Surfaces

- Yactrax® (Yaktrax, Inc. Morrisville, NC)
- Reduced risk of falls outdoors during winter for older individuals McKiernan, 2005
- Warning against wearing indoors on hard surfaces (e.g., tile)
- Apply to dedicated shoes.

Slipping
Step Length

\[ F_{\text{max}} = \mu \times N \]

As step length increases, required coefficient of friction to prevent slipping increases. Cooper et al, 2008.

Slipping
Summary

- Avoid very hard sole materials
- Wear shoes with wider and deeper tread surfaces
- Wear shoes with rougher sole surfaces
- Take shorter step lengths
- Yactrax®

Risk for Falling

- Limited research secondary to prospective study design.
- Personnel to follow large subject samples and conduct interviews soon after fall event to record circumstances of the fall.
  - Activity being performed
  - Support surface conditions
  - Shoe wear characteristics
- Really have only three studies.

Risk for Falling

- Subjects more likely to fall indoors if they were barefoot or wearing socks compared with wearing shoes
- Base of support and coefficient of friction are likely issues.
Risk for Falling

- Koepsell et al (2004) followed 1,371 adults age 65 and older over two years
- Supported findings of Menz et al (2006) by detecting sharp rise in risk for falling when subjects were either barefoot or wearing only socks indoors
- Risk for falls reduced when subjects wore athletic type shoes compared with other shoe types.

Risk for Falling

- Tencer et al (2004) studied same 1,371 subject sample followed by Koepsell et al
- Increased falls risk with increased heel height - supports balance research
- Greater surface area of sole material associated with decreased falls risk - consistent with balance research in increasing base of support

Risk for Falling

- Kerse et al (2004) studied 606 older adults (mean age 83 years) living in residential care facilities.
- Slippers associated with increased risk for falling indoors compared with wearing shoes.

Risk for Falling

Summary

- Wear shoes
- Avoid walking indoors in bare feet or in socks alone
- Wear shoes with lower heel height
- Wear shoes with greater surface area for the sole materials
- Wear athletic type shoes
- Avoid wearing slippers.

Shock Absorption

- Relate to concerns for reducing muscle-tendon force requirements and joint loads at impact
- Health of articular cartilage and THA and TKA components
- Shock absorbing shoe is effective and inexpensive method for protection of total joint components. Gabauer & Cziuk, 1988

Impulse-Momentum Equation

\[ F \cdot \Delta t = m \cdot \Delta v \]

- Key, therefore, to minimizing GRFs involves deformation of shoe sole materials over the longest period of time possible.
- Mid-range stiffness desirable, since materials that are too stiff or that have too little stiffness deform more quickly.
- Ah!!! 'Goldie Locks' porridge business again.
Shock Absorption
For athletic shoes that are more protective against falls (Koepsell et al, 2004) manufacturers attempt to prolong $\Delta t$:
- Air cells
- Gel cells
- Ethylene vinyl acetate (EVA) secondary to flow of air through interconnecting cells within the material (Even-Tzur et al, 2006)

Shock Absorption
EVA
- Shock absorbing capability compromised with continued use as air cells collapse
- Reduced thickness of EVA sole most important factor in increased compressive stress on heel during impact (Even-Tzur et al, 2006)
- Older individuals should select athletic shoes with thicker sole materials, with moderate stiffness values, and should replace their shoes following prolonged use
- Prolonged Use?

Shock Absorption
Cook et al, 1985- laboratory bench testing and testing by runners
- Running shoes retained 70% of shock absorbing capability after 500 miles of running
- Shoes that were initially superior in their shock absorbing capability demonstrated more rapid decline with use
- Shoe sole material may also stiffen with age even if not used frequently.

Shock Absorption
Dib et al (2005) found that shoes with air cells, gel cells, and EVA designed to provide shock absorption all demonstrated exponential losses in shock absorbing capability as temperature of the shoe’s midsole material decreased.
- Older individuals who require shock absorbing capabilities from their shoes should perform weight bearing exercise indoors during periods of colder weather.

Shock Absorption
Summary
- Wear athletic shoes with mid-range stiffness values for midsole materials
- Wear shoes with thicker midsole materials
- Replace shoes after prolonged use- the "gardening shoe" rotation
- Perform weight bearing exercise indoors during colder weather.

Knee Osteoarthritis (OA)
Frontal plane loading of the knee is tied to relationship with foot pronation and supination.
Frontal Plane Knee Loading with Foot Pronation

Culprit is Moment Arm for GRF

Medially wedged foot orthoses and supportive shoes are capable of reducing valgus loading for individuals with lateral compartment OA. Rodrigues et al, 2008

Medial Compartment Knee OA

- Individuals with medial compartment OA, simply wearing shoes with any support at all increases medial compartment compressive stress compared with walking in bare feet Kemp et al, 2008
- Special shoes with very flexible uppers and grooves cut into sole material resulted in less varus loading than a supportive shoe Shakoor et al, 2008

Knee Osteoarthrosis (OA)

Supportive shoes (L) and flexible shoes (R) from Shakoor et al, 2008.

Medial Compartment Knee OA

- Varus loading is reduced with laterally wedged insoles Shimada et al, 2006 & Kakihana et al, 2005
- Also benefit from laterally wedged insoles combined with wearing very flexible shoes Kakihana et al, 2005
- Some of the beneficial effects of the lateral wedge insole are negated by wearing shoes with heel lift Toda & Tsukimura, 2008

Heel Lift and Knee Loading

- Kerrigan et al (2005) studied effects of 3.8 cm heels (1.5 in) on knee loading
  - Increased varus loading from GRF
  - Increased flexion loading from GRF
- Plantar flexion is a component of supination—therefore troublesome for medial compartment knee OA
- Troublesome for patellofemoral joint OA secondary to increased quadriceps muscle activation in greater positions of knee flexion.
Knee OA Summary

- Medial Compartment OA
  - Use laterally wedged insoles
  - Wear flexible shoes that have NO motion control features
  - Avoid shoes with heel lift
- Lateral Compartment OA
  - Use medially wedged insoles
  - Wear very supportive shoes that resist pronation

Hallux Rigidus

Pronounced hypomobility first MTP joint often secondary to reactive bone formation on dorsal aspect of articulation (Haddad, 1999). Patient reminded at terminal stance.

- Benefited from rocker bottom shoe with only the anterior portion of the rocker
- Benefited also from stiff sole material
- Similar recommendations by Haddad (1999)

Clinical Experience
- Stiff Toe Break
- Orthotic with relief under first toe to limit extension
- Use of rigid sole plate to limit extension

Rocker Bottom Shoe used to decrease demand for MTP joint extension for Hallux Rigidus or other conditions in which MTP joint extension is limited/painful.

Rocker Bottom Shoe – The Etonic Minado®

Testing the Toe Break for Stiffness to Bending
Hallux Rigidus

Relief created within a foot orthosis underneath the great toe to limit MTP joint extension during terminal stance.

Hallux Rigidus

Rigid sole plate added to the bottom of a foot orthosis to limit MTP joint extension during terminal stance.

Hallux Rigidus

Summary

- Rocker bottom sole
- Stiffness within the sole materials at the toe break of the shoe
- Foot orthotic with relief underneath the great toe
- Rigid sole plate to limit 1st MTP extension

General Fit Recommendations

Length - The “Rule of Thumb” from Barton et al, 2009

General Fit Recommendations

And Fixation Methods

- Depth of toe box assessed by free movement of toes up and down and no pressure on dorsal aspect of toes or nails. Barton et al, 2009
- Difficulty donning and tying shoe laces
  - Long-handled shoehorns
  - Velcro closures from manufacturer or added later by shoe repair shop
  - Long-handled grabbing device to secure Velcro straps

Width - Bunching across metatarsal heads - Barton et al, 2009
Summary of General Recommendations

- Athletic shoes- wear them
- Avoid bare or stocking feet
- Thick soles with medium stiffness values
- Avoid elevated heel heights
- Rough sole surfaces with wide and deep treads
- Increased surface area of sole materials
- Higher collar on the foot and ankle
- Assess the patient for specific needs based on these issues and musculoskeletal condition!!