ORTHOTICS AND MOBILITY

Tina Duong, MPT, PhDc
Outline

- Leg Anatomy
  - Muscle Imbalances
- Biomechanics
  - Clinical symptoms
    - Muscle Imbalances: Ankle tightness/contractures
    - Gait/Walking
      - Stability or Balance
      - Energy Expenditure
- Treatment options for lower leg weakness
  - Exercise, Stretching, Orthosis
- Orthosis
  - Ground Reaction Forces
  - Choosing the right orthosis
Quick Fire: Mobility options

- Transfer Devices
- Upper Extremity Supports
- Power and Manual Mobility Devices
Let's get on the same page...

**Side View**

Dorsiflexion

Plantar flexion

**Front View**

Inversion

Eversion

**Hind View**

Rearfoot Valgus

Rearfoot Varus
Leg Anatomy

Dorsiflexors:
Tibialis Anterior, Extensor hallucis longus, Extensor Digitorum Longus

Plantarflexors:
Gastrocnemius and Soleus
2 Phases of Gait (walking)

Stance Phase

Midstance

Ankle joint motion (degrees)

Percent of gait cycle

DORSIFLEXION

PLANTAR FLEXION

PUSH OFF

Swing phase

Heel contact

Foot flat

Heel off

Toe off

Stance Phase
Stance Phase: Rocker Phases

Heel strike

Loading response
Eccentric control of quads and TA
Eccentric Gastroc/soleus to control tibia

Push Off/Toe off
Contraction of Gastroc/soleus (power)
Objectives in Gait

- Move from one place to another safely
- Use the least amount of energy to move
  - Forward motion
    - Rigid foot lever arm to propel body forward
    - Muscles to control movement
  - Limit vertical motion
- Limit Pain/discomfort
Management of ankle foot muscle weakness

- No intervention
  
- Physical therapy
  - Stretching:
    - Maintenance of range of motion (ROM)---tight Achilles tendon
  - Strengthening to improve active muscle movement
  - Balance

- Orthotics
  - Static
  - Dynamic

Sackley et al 2009
## Stretching and Orthotics in ROM

- **DMD Cohort**
- **Solid AFO** or stretching orthosis used daily significant effect on ankle range of motion

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N</th>
<th>Mean ± SD</th>
<th>Median (range)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRETCHING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have used</td>
<td>43</td>
<td>-6.0 ± 13.10</td>
<td>0 (-35 – 15)</td>
<td>0.008</td>
</tr>
<tr>
<td>Daily use</td>
<td>89</td>
<td>1.0 ± 10.7</td>
<td>0 (-45 – 20)</td>
<td></td>
</tr>
<tr>
<td><strong>NIGHT SPLINTS</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Have used</td>
<td>33</td>
<td>-7.7 ± 15.0</td>
<td>-5 (-45 – 15)</td>
<td>0.006</td>
</tr>
<tr>
<td>Daily use</td>
<td>83</td>
<td>0.4 ± 9.7</td>
<td>0 (-30 – 15)</td>
<td></td>
</tr>
</tbody>
</table>

*p-value from non-parametric comparison using Wilcoxon rank sum test (Duong, Unpublished 2016)
Physiology of Stretch

- Slow Sustained pressure = most effective stretch
Strengthening: DM

- **24 week strength training program (RCT)**
  - No effect on walking speed or stairs
  - Reported improvements on ADLs
  - No negative effects

- **12 Week aerobic training** (Orngreen et al 2005)
  - Improvement oxygen uptake by 14%
  - Muscle fiber size increased
Benefits of Exercise

Healthy Individuals

- **Aerobic Endurance**
  - 30 minutes VO2max 50-85%
  - Improved circulation, oxygen usage, oxidative phosphorylation (Timmons et al, 2010)
  - 30min of moderate exercise, 5/week decreased mortality rates (Whitehead et al, 1995)

- **Strength training**
  - Increased muscle strength and power, increase lean body mass

Individuals with NMD

- Adaptations to exercise in NMD similar to sedentary population (Mcdonald et al, 2002, Fowler 2002)

- **Goals:**
  - Improve/maximize function
  - Fall prevention/balance
    - Weakness/sensory impairments
  - Minimize Pain
  - Improve sleep
  - Minimize development of contractures
Back to orthotics...
You may need a brace if...

- Steppage gait
-Dragging of the foot and toes
-Scraping of the toes across the ground
-Uncontrolled slapping of the toes against the ground
-Unable to walk normally in heel-to-toe fashion

- The inability to raise the foot at the ankle
- The inability to point the toes upward at the body (dorsiflexion)
Goal of Orthotics or Bracing

- Improve walking efficiency
  - Use less energy
- Foot clearance during walking
- Walking speed
- Maintain range of motion
- Improved stability
What type of orthosis works for me?
Considerations

ICF: Interaction of Concepts

Health Condition
(disorder/disease)

Body functions &
structures
(Impairment)

Activities
(Limitation)

Participation
(Restriction)

Environmental
Factors

Personal
Factors
Body Structure/Function (impairment)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Concerns</th>
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</thead>
<tbody>
<tr>
<td>Joint integrity and stability</td>
<td>Ligamentous instability, joint deformity</td>
</tr>
<tr>
<td>Range of motion</td>
<td>Soft tissue contracture, joint deformity</td>
</tr>
<tr>
<td>Muscle length</td>
<td>Fixed versus modifiable contracture</td>
</tr>
<tr>
<td>Overall flexibility</td>
<td>Ability to don/doff; impact of orthosis on trunk, back</td>
</tr>
<tr>
<td>Muscle performance</td>
<td>Strength, power, endurance</td>
</tr>
<tr>
<td>Involuntary movement</td>
<td>Impact on tolerance of orthosis</td>
</tr>
<tr>
<td>Coordination</td>
<td>Ability to don/doff</td>
</tr>
<tr>
<td>Upper extremity function</td>
<td>Ability to don/doff</td>
</tr>
<tr>
<td>Postural control, balance</td>
<td>Ability to don/doff</td>
</tr>
<tr>
<td>Visual function</td>
<td>Ability to perform skin checks, donning/doffing</td>
</tr>
<tr>
<td>Cognitive function</td>
<td>Understanding of how to use orthosis</td>
</tr>
<tr>
<td>Cardiovascular endurance</td>
<td>Ability to functionally use orthosis</td>
</tr>
<tr>
<td>Domain</td>
<td>Concerns</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------</td>
</tr>
<tr>
<td>Gait analysis</td>
<td>Primary gait problems and compensations</td>
</tr>
<tr>
<td></td>
<td>Impact of orthosis on physical work of walking</td>
</tr>
<tr>
<td></td>
<td>Safe function with orthosis and assistive device</td>
</tr>
<tr>
<td></td>
<td>Impact of resistance, unstable surface on gait</td>
</tr>
<tr>
<td>Activities of Daily Living</td>
<td>Don/doff orthosis</td>
</tr>
<tr>
<td></td>
<td>Self care</td>
</tr>
<tr>
<td></td>
<td>Orthosis management with clothes ie: shoes</td>
</tr>
</tbody>
</table>
## Participation Level

<table>
<thead>
<tr>
<th>Domain</th>
<th>Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>Roles and participation in family tasks</td>
</tr>
<tr>
<td>School</td>
<td>Impact of classroom, walking through hallways, play areas</td>
</tr>
<tr>
<td>Work</td>
<td>Entering in buildings, workspace, common areas</td>
</tr>
<tr>
<td>Leisure</td>
<td>Hobbies</td>
</tr>
<tr>
<td>Transportation</td>
<td>Drive, public transportation</td>
</tr>
</tbody>
</table>
Takes a team

- Patient/Caregiver
  - Where will you wear it?
  - How do you put it on? Take it off?

- Physician
  - Understanding of disease mechanisms and progression

- Physical Therapist
  - Strength and function
  - Biomechanics of movement

- Orthotist
  - Materials
  - Biomechanics
Orthotic Considerations

- **What is the objective of the orthosis?**
  - Support/stability
    - Control movement
  - Correct deformities
    - Minimize mal-alignment
  - Compensate for weakness
    - Improve gait, safety
    - Endurance (energy efficient gait)

- **Comfort and Cosmesis**
  - Short vs. long term
  - Low profile
  - Custom molded vs. off the shelf

- **Cost** (fabrication and maintenance)
  - Insurance or out of pocket
What do AFOs do?

- Usually prescribed for
  - Ankle dorsiflexion weakness through swing phase
  - Ankle Plantar flexion weakness during stance phase

- How?
  - Supports forefoot from dropping into plantarflexion during swing
    - Energy efficient, Safety
Options

- Fixed
- Articulated/hinged
- Energy storing: Carbon fiber
- Neuroprosthetics
  - Functional Electrical Stimulation
    - Walkaide, Ness 300 foot drop system, Odstock
    - Stimulates peroneal nerve to initiate dorsiflexion
    - Initiated through EMG sensors, IMU sensors
- Materials
  - Leather, thermoplastic, carbon fiber
- Biomechanics
  - Ankle in neutral
  - In Plantarflexion
    - Extensor moment
  - In Dorsiflexion
    - Flexor moment
- Other types of orthoses
  - Shoe inserts
  - SuperMalleolar Orthosis (SMO)
  - Knee ankle foot orthosis (KAFO)
  - Hip Knee ankle foot orthosis (HKAFO)
Minimal AFOs

- **Foot ups**
  - Supports foot into dorsiflexion
  - Low profile

- **Fixed short leg AFOs**
  - Flat foot
  - Keeps foot at 90 degrees
  - Not recommended for tall individuals 6’
  - Keeps foot at 90 degrees so gait abnormal

- **Dorsiflexion Assist short leg AFOs**
  - Spring like hinge to help with dorsiflexion
  - recommended for tall individuals 6’ or 225 lbs.
Long AFOs

- **AFO with plantarflexion stop**
  - Allows normal dorsiflexion
  - Has stop to not allow plantarflexion

- **Solid AFO (traditional)**
  - For dropfoot and knee weakness
  - Keeps foot in fixed position
  - Stability during stance phase

- **Anterior shelf**
  - Prevents knee collapse
  - Need good hip extension strength
Carbon Fiber AFO

- **Energy return AFOs**
  - Carbon fiber
  - Light
  - Energy return at toe off (push off)
  - Lack lateral stability support
  - Normal Heel biomechanics

- **Not optimal for**
  - Achilles tendon contractures

- **Decrease energy expenditure & Improve Gait speed**
  - Danielson et al 2004
  - Danielsson et al 2010
  - Bartonek et al 2007

- **NM Clinic Pilot study indicates patient satisfaction**
  - Mnatsakanian et al 2017
Ground Reaction Force: How it affects your ankle and knees

- **Ground Reaction Force (GRF)**
  - Force exerted by the ground on the body
  - Newton’s 3\textsuperscript{rd} law
    - $F$ on ground exerts $\Rightarrow$ and opposite reaction

- **Mid stance and toe off**
  - Plantarflexors active to counter dorsiflexion moment produced by ground reaction force
    - Weak plantarflexors $\Rightarrow$ knee flexion $\Rightarrow$ decrease stability
  - Solid AFO: Translates GRF from the ground to front of tibial
    - Plantarflexion moment
Upper Extremity Supports, Mobility Devices, Transfer Devices

Thank you to Leslie Vogel, Claudia Senesac and Laura Case for contributions to the Equipment slides.
Hand splints

- To stretch wrist/finger flexors
- To stretch finger extensors
- To prevent PIP hyperextension

Benik splints

Figure 8 oval splints
Functional Arm Supports

Mechanical- require some strength to elevate

- **WREX** (rubber band tension)
  - [http://jaecoorthopedic.com](http://jaecoorthopedic.com)

- **X-Ar exoskeletal arm** (springs and tensioning hardware)
  - Not currently on the market
Powered Arm Supports: Requires some strength

- **Neater Arm with Assist**
  - [http://www.neater.co.uk/neater-arm-support](http://www.neater.co.uk/neater-arm-support)

- **Go Wing Arm Support**
  - [http://www.innovationshealth.com/gowing](http://www.innovationshealth.com/gowing)
Robotic Arms: No strength requirement

JACO Robotic Arm

http://www.kinovarobotics.com/about-us
https://www.youtube.com/watch?v=IB-ZIuvrQgk#t=106
Early Mobility Devices

Go-Go Scooter

- More portable than w/c
- Negatives
  - Poor seating support
  - Large turning radius
  - UE fatigue
- Mobility not Seating device

http://www.pridemobility.com/gogo/

Go-Go® Elite Traveler Plus
Alternative motorized systems

EZ Lite Cruiser

http://www.ezlitecruiser.com/
Alternative motorized systems

Zappy

- more portable than w/c
- can stand or stand
- ~13 mph

http://www.zapworld.com/vehicles/zappy-pro-flex-500
Alternative motorized systems

EV Stand & Ride

- more portable than w/c
- can sit or stand
- \(\sim\) 15 mph

http://evrider.com
Portable power assist wheelchairs

Efix

E motion power assist or twion power assist

Smart Drive

http://www.alber-usa.com
Additional power adaptations

Firefly

- Attaches to manual wheelchair
- Difficult to transfer into chair with device
- ~12 mph

http://riomobility.com/
Power Wheelchair purchase

- Drive Mechanism
  - Front wheel
  - Mid-wheel
  - Rear wheel

- Power Options
  - Power standing feature
  - Power tilt and/or recline
  - Power seat elevation
  - Separately elevating power elevating leg rest
Supported Standing

Stand & Drive chairs

Permobil F5 stand & drive
www.permobilus.com/f5vs.php
Other retailers

Redman standing powerchairs
www.redmanpowerchair.com

Levo C3 Standing Chair
levousa.com
Standing frames

EasyStand stander
EasyStand.com
Hydraulic Patient Lifts

Drive Deluxe Silver Vein Patient Lift
Hoyer Hydraulic Patient Lifter
Powered Patient Lifts

Drive Medical Power Patient Lift

Invacare Reliant 450 Battery
Standing Transfer Aids

Easy Pivot

Rifton-Tram
Ceiling Lifts

Surehands

Barrier Free
Joerns Voyager Portable Track

Bath bracket

Ceiling Mounted
Joerns Voyager Portable Track

Post-mounted
Free Standing Tract Lifts

Norco-Inc.

Prism Medical
Slings

Universal Sling

Full Body Sling

- Solid or Mesh
- Head Support
Transfer sheets

Alpha-Modalities

Arjo MaxiSlide

ErgoSlide
Prismmedicalinc.com
Toilet Adaptations

- Toilevator
- Aerolet toilet lift
- Toilet Arm Rests
- Washlet / bidet
Bathroom Transfers

Walmart/Amazon $50- $90

Slider systems
Bathroom Transfers

Columbia Ultima Access

http://www.inspiredbydrive.com
Tubbuddy with tilt

www.myshowerbuddy.com
Bathroom Transfers - Rifton

Rifton Bath-Commode Chair

Rifton Blue Wave Tub Transfer Base - 2017
Rolling Shower/Commode

ActiveAid 285TR
www.activeaid.com

RAZ-AT (Attendant Tilt)
http://razdesigninc.com
Adapt Environment as Necessary

Enjoy LIFE…Don’t struggle when you may not have to
QUESTIONS?

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