Osteopathic Rehabilitation: Where Should We Start? Biomechanical Modeling Approach

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NCMRR Rehabilitation Domains
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Societal Limitation

Disability

Functional Limitation

Impairment

Pathophysiology
Pathophysiology:

*Interruption of or interference with normal physiological processes or structures at the cell and tissue level*
Impairment:

Loss or abnormality of …anatomical structure or function, including all losses or abnormalities, not just those attributed to the initial pathophysiology.
Impairments

- Joint Range of Motion
- Muscle Strength
- Pain
Functional Limitation:

Restriction or lack of ability to perform an action in the manner or within the range consistent with the purpose of an organ or organ system.
Functional Limitation

- Slowness of movement
- Unsteadiness
- Tripping
Disability:

Inability or limitation in performing tasks, activities, and roles to levels expected within physical and social contexts.
Disability

- Inability to go shopping
- Inability to attend school
- Inability to participate in sports
Societal Limitation:
Restriction, attributable to social policy or barriers (structural or attitudinal), which limits fulfillment of roles or denies access to services and opportunities that are associated with full participation in society.
NCMRR Rehabilitation Domains

- Societal Limitation
- Disability
- Functional Limitation
- Impairment
- Pathophysiology
Important Conceptual Points

• This is an impairment driven model not a pathology driven model.

• The rehabilitation goal is typically to maintain or restore maximum function. The goal is seldom to restore normal movement or normal movement control.
Level of Impairment

Increase

Decrease

Ability to Perform Movement Task

Functional Limitation

Disability
<table>
<thead>
<tr>
<th>Level of Impairment</th>
<th>Ability to Perform Movement Task</th>
<th>Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>Functional Limitation</td>
</tr>
<tr>
<td>Decrease</td>
<td>Decrease</td>
<td>Disability</td>
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The graph shows the relationship between level of impairment and ability to perform movement task. As impairment increases, the ability to perform the task decreases, leading to increased disability.
Level of Impairment

Movement Demands

Ability to Perform Movement Task

Increase

Decrease

High

Low

Functional Limitation

Disability
Level of Impairment

- High
- Low

Disability

- Increase
- Decrease

Ability to Perform Movement Task

Available Movement Strategies

Functional Limitation
Gait Lab Set Up
A moment at a joint will act to accelerate all of the joints of the body.
Biomechanics Model

\[
\tau_1 = M_{11} \ddot{\theta}_1 + M_{12} \ddot{\theta}_2 + C_{11} + C_{12} + G_1 \\
\tau_2 = M_{21} \ddot{\theta}_1 + M_{22} \ddot{\theta}_2 + C_{21} + C_{22} + G_2
\]

\[
\begin{bmatrix}
\tau_1 \\
\tau_2
\end{bmatrix} =
\begin{bmatrix}
M_{11} & M_{12} \\
M_{21} & M_{22}
\end{bmatrix}
\begin{bmatrix}
\ddot{\theta}_1 \\
\ddot{\theta}_2
\end{bmatrix} +
\begin{bmatrix}
C_{11} & C_{12} \\
C_{21} & C_{22}
\end{bmatrix} +
\begin{bmatrix}
G_1 \\
G_2
\end{bmatrix}
\]
Knee Function in Gait

- In healthy subjects, the knee extensors are responsible for preventing knee collapse during walking.

- In patients with weakness, other muscle groups must be used to control the knee indirectly.
Objective

• Examine the compensatory strategies used during the early stance phase of gait by a series of three patients with knee extensor weakness
Objective

Apply principles:

- a moment at one joint can accelerate all joints
Patient #1 - History

• 16 year old male
• Impairments: muscle weakness in knee extensors (3+/5) and ankle plantar flexors (unable to rise up on toes)
Patient #1 - Gait
Patient #1 - Motion and Moments

Angle | Ankle (dfl+) | Knee (ext+) | Hip (fl+)

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<tr>
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<td>0.5</td>
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<td>N.m/kg</td>
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Patient #1 – Knee Control

- Sources of knee flexion
  1. gravity
  2. ankle dorsiflexors
  3. knee flexors
Patient #1 – Knee Control

- Sources of knee extension
  1. hip extensors
Patient #1 – Knee Control

Knee Acceleration

Flexion sources
- Total
- Gravity
- Ankle
- Knee
- Hip

Extension sources
- Total
- Gravity
- Ankle
- Knee
- Hip

-100 -50 0 50 100 150 200
rads/s/s
Patient #1 – Knee Control

- Sources of knee extension
  1. Hip extensors

- Sources of knee flexion
  1. Gravity
  2. Ankle dorsiflexors

- Net effect: knee extension
Patient #2 - History

- 29 year old male

- Impairments: muscle weakness in knee extensors (2/5) hip flexors (2/5) and other hip muscles (4-/5)
Patient #2 - Gait
Patient #2 - Motion and Moments

**Angle**
- Ankle (dfl+)

**Moment**
- Ankle (dfl+)
- Knee (ext+)
- Hip (fl+)

_deg_  

_0_  

_-30_  

_-30_  

_0_  

_-30_  

_N.m/kg_

_0.5_  

_-2.0_  

_% stance_

_0_  

_50_  

_100_  

_% stance_

_0_  

_50_  

_100_  

_% stance_
Patient #2 – Knee Control

- Sources of knee flexion
  1. gravity
  2. knee flexors
Patient #2 – Knee Control

• Sources of knee extension
  1. hip extensors
  2. ankle plantar flexors
Patient #2 – Knee Control

Knee Acceleration

- Extension sources
- Flexion sources

rads/s

Total Gravity Ankle Knee Hip
Patient #2 – Knee Control

• Sources of knee extension
  1. Ankle plantar flexors
  2. Hip extensors

• Sources of knee flexion
  1. Gravity

• Net effect: knee extension
Patient #3 - History

• 54 year old male
• Impairments: muscle weakness in left lower extremity (2/5) and right lower extremity (4/5)
Patient #3 - Gait
Patient #3 - Motion and Moments

### Angle

**Ankle (dfl+)**
- Degree: 30
- Moment: 0.5

**Knee (ext+)**
- Degree: 10
- Moment: 1.0

**Hip (fl+)**
- Degree: 40
- Moment: 1.0

### Moment

- N.m/kg
- % stance
Patient #3 – Knee Control

- Sources of knee flexion
  1. gravity
Patient #3 – Knee Control

- Sources of knee extension
  1. hip extensors
  2. contralateral ankle plantar flexors
Patient #3 – Knee Control

Knee Acceleration

Extension sources

Flexion sources

-100
-50
0
50
100
150
200
rads/s/s

Total
Gravity
Ankle
Knee
Hip
Patient #3 – Knee Control

• Sources of knee extension
  1. Contralateral ankle plantar flexors
  2. Hip extensors

• Sources of knee flexion
  1. Gravity

• Net effect: knee extension
Conclusions

• Each muscle group can accelerate all joints within the limb and in the contralateral limb

• Patients with weakness can alter joint position and increase use of other muscle groups to compensate for lost function
10 most common complementary health approaches among adults—2012

- Natural Products*: 17.7%
  - Deep Breathing: 10.9%
  - Yoga, Tai Chi, or Qi Gong: 10.1%
  - Chiropractic or Osteopathic Manipulation: 8.4%
  - Meditation: 8.0%
  - Massage: 6.9%
  - Special Diets: 3.0%
  - Homeopathy: 2.2%
  - Progressive Relaxation: 2.1%
  - Guided Imagery: 1.7%

* Dietary supplements other than vitamins and minerals
