Examination of the Increased Risk of Knee Pain and Osteoarthritis in Amputee Populations

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Purpose

• To demonstrate that a higher prevalence of knee pain and OA exists in the intact limb of amputees than to that of nonamputees
• To provide evidence on how this secondary disability can further impact function
• To provide evidence on how strength and gait abnormalities may contribute to developing this secondary disability
• To demonstrate how such evidence may impact the care of my patient
Patient Introduction & History

- 53 y/o male admitted to acute care facility s/p L Total Knee Arthroplasty
- Medical Dx: OA of the L knee
- Precautions: WBAT
- Right transfemoral amputation 40 years prior
- Relatively insignificant medical history otherwise
Initial Evaluation

Subjective
• Independent with ambulation (prosthesis and/or crutches), bed mobility, transfers, & ascending/descending stairs.
• Able to participate in all desired functional and social activities
• Lives in a 1 story house with his wife with 2 steps to enter home.
• All necessary DME at home.

Objective Measures
• L Knee PROM:
  • Flexion: 80 degrees
  • Extension: Lacking 15 degrees
• Bilateral UE AROM & Strength:
  • Within Functional Limits
Assessment
ICF Model

Left TKA
Right AKA

- Left Knee Pain & Stiffness
- Decreased L. knee ROM
- Decreased L. quadriceps strength
- Inability to bear weight on R. LE

- Decreased independence w/ bed mobility, transfers, & ambulation.
- Decreased ability to ascend/descend stairs.
- Decreased independence in donning prosthesis

- Unable to independently ambulate in community and to participate in social activities as prior to admission

Strong support system at home
Motivated to return to prior level of function
ICF Model

Left Knee Pain and Stiffness

- Decreased bed mobility and transfer ability sit to stand.
- Decreased ROM
- Decreased ability to functionally ambulate.
- Decreased ability to ascend and descend stairs.

- Strong support system at home

Left TKA
Right AKA

- Decreased ability to adhere to surgical precautions while donning prosthesis and ambulate in community safely.
- Unable to independently ambulate to participate in hobbies, such as gardening.

- Motivated to return to prior level of function
Assessment – Goals

• Short Term: (By discharge)
  • Increase independence with bed mobility and transfers
  • Increase adherence to surgical precautions while donning prosthesis without assistance
  • Ambulate 200 ft independently with assistive device
  • Independently ascend/descend stairs safely with assistive device

• Long Term:
  • Return to prior level of function/participation as described by patient (i.e. gardening)
Plan of Care

- Treatment BID to progress towards goals with following interventions:
  - Bed exercises (post-TKA)
  - Bed mobility & transfer training
  - Practice donning prosthesis while maintaining WBAT
  - Gait training

- Upon D/C:
  - Recommended Home Health PT

- Key Aspects:
  - Patient preferences
  - Patient education
Clinical Question

Is a transfemoral amputation a predictor of an increased risk of developing knee osteoarthritis in the intact lower extremity?
Existing Evidence

• Numerous studies support that a transfemoral or transtibial amputation can increase the risk of developing knee OA on the contralateral, intact limb:
  • 65.6% prevalence in intact limb vs 37.5% in dominant limb of control group. Results in prevalence ratio 1:8. (Melzer et al)
  • 83% prevalence in intact limb of transtibial amputees vs 50% in control group. Results in prevalence ratio of 1:7. (Lemaire and Fisher)
  • 63%, 41%, and 21% prevalence in intact limb transfemoral amputees, transtibial amputees, and control group respectively. Results in prevalence ratio of 3.0 and 2.0 for transfemoral and transtibial respectively. (Hungerford and Cockin)

However, these studies lack evidence in regards to how this secondary disability impacts patients function as well as the specific mechanisms that contribute to the higher risk in the amputee population.
"The Prevalence of Knee Pain and Symptomatic Knee Osteoarthritis Among Veteran Traumatic Amputees and Nonamputees"

Norvell DC, Czerniecki JM, Reiber GE, Maynard C, Pecoraro JA, Weiss NS.

• Objectives:
  • To determine whether amputees have an increased risk of knee pain or symptomatic OA compared with nonamputees.
  • To compare the functional impact of knee pain and OA in both populations.
    • This is the first report of knee pain and its influence in functional activities in amputee populations.
Methods
Retrospective cohort study

• Compared the intact and amputated limb knees of male veterans with traumatic amputations to knees of male veteran nonamputees.

• Inclusion Criteria
  • 40 y/o or older, Male
  • Traumatic transtibial or transfemoral amputees and ambulated with prosthesis for at least 5 years
  • No other LE injuries or other rheumatic disease

<table>
<thead>
<tr>
<th>Table 1: Descriptive Characteristics of Amputees and Nonamputees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Continuous variables (mean ± SD)</td>
</tr>
<tr>
<td>Age (y)</td>
</tr>
<tr>
<td>Height (m)</td>
</tr>
<tr>
<td>Weight at age 18 (kg)</td>
</tr>
<tr>
<td>Average weight (kg)*</td>
</tr>
<tr>
<td>BMI at age 18 (kg/m²)</td>
</tr>
<tr>
<td>Average BMI (kg/m²)*</td>
</tr>
<tr>
<td>Categoric variables, n (%)</td>
</tr>
<tr>
<td>Gait aid*</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

Abbreviation: SD, standard deviation.
*Mean of age 18 and age 30.
*Currently using a cane, walker, crutch, or other aid for ambulation.
Methods
Retrospective cohort study

- Data was collected via telephone
- Questions based on the American College of Rheumatology criteria for knee OA

<table>
<thead>
<tr>
<th>Suffering from knee pain “most of the time”?</th>
<th>62 amputees (44 TTA, 18 TFA)</th>
<th>94 nonamputees met study criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>15 days in past month; continuous or intermittent</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>10 amputees</td>
<td>11 nonamputees</td>
</tr>
<tr>
<td>1. Knee stiffness 30 mins of less in AM?</td>
<td>YES</td>
<td>Dx: Symptomatic OA</td>
</tr>
<tr>
<td>2. Sounds or feelings of rubbing or crunching?</td>
<td>NO</td>
<td>Dx: Knee Pain</td>
</tr>
<tr>
<td></td>
<td>25 amputees</td>
<td>19 nonamputees</td>
</tr>
</tbody>
</table>
Methods

- Chronic Pain Grade (CPG) Questionnaire
  - Assess two dimensions of chronic pain severity: pain intensity and pain-related disability
  - Pain intensity and pain interference items scored on scale 0-10. Also # of disability days.
  - 5 Categories/Grades: 0 (no pain) to IV (high disability-severely limiting)
Results

Functional Impact of Pain

• The overall functional impact of knee pain was generally more severe among nonamputees than amputees.
  - Nonamputees reported significant interference with recreational, social, and family activities compared to non amputees
  - Amputees reported a lower average intensity of knee pain

Table 4: Results From the CPG Questionnaire Comparing Amputees With Nonamputees in Those Subjects Who Complained of Knee Pain*

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Amputees (n=25)</th>
<th>Nonamputees (n=16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain intensity items* (mean ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present pain</td>
<td>3.5±2.5</td>
<td>4.9±2.9</td>
<td>.09</td>
</tr>
<tr>
<td>Worst pain</td>
<td>7.6±2.0</td>
<td>7.3±2.6</td>
<td>.63</td>
</tr>
<tr>
<td>Average pain</td>
<td>4.9±2.0</td>
<td>5.9±2.0</td>
<td>.14</td>
</tr>
<tr>
<td>Disability days, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6</td>
<td>16 (64)</td>
<td>10 (63)</td>
<td>.43</td>
</tr>
<tr>
<td>7–14</td>
<td>3 (12)</td>
<td>4 (25)</td>
<td></td>
</tr>
<tr>
<td>15–30</td>
<td>2 (8)</td>
<td>1 (6)</td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>4 (16)</td>
<td>1 (6)</td>
<td></td>
</tr>
<tr>
<td>Interference items† (mean ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily activities</td>
<td>2.8±2.9</td>
<td>3.8±3.1</td>
<td>.28</td>
</tr>
<tr>
<td>Recreation</td>
<td>2.6±3.4</td>
<td>6.4±4.1</td>
<td>.00</td>
</tr>
<tr>
<td>Work</td>
<td>2.9±3.5</td>
<td>4.5±3.9</td>
<td>.16</td>
</tr>
<tr>
<td>CPG classification, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>0</td>
<td>0</td>
<td>.45</td>
</tr>
<tr>
<td>Grade I</td>
<td>7 (28)</td>
<td>3 (19)</td>
<td></td>
</tr>
<tr>
<td>Grade II</td>
<td>10 (40)</td>
<td>6 (38)</td>
<td></td>
</tr>
<tr>
<td>Grade III</td>
<td>4 (16)</td>
<td>5 (31)</td>
<td></td>
</tr>
<tr>
<td>Grade IV</td>
<td>4 (16)</td>
<td>2 (12)</td>
<td></td>
</tr>
</tbody>
</table>

*The last 6 months were used to assess each dimension.
†Three (15.8%) nonamputee subjects refused or could not rate their CPG items.
‡Subjects were asked to rate these items on a scale of 0 to 10.
Chi-square test for trend (1 degree of freedom).
Discussion
Functional Impact of Pain

- Possible Reasons:
  - Amputees focus more on adapting to their primary disability and less on the functional impact of their secondary disability.
  - Amputees participate less in recreational activities than nonamputees.
  - Amputees view their secondary disability as less debilitating.
  - Regardless, any of the reasons above would indicate an underreporting of functional interference and pain intensity by amputees in patient-rated measures.
Results

The prevalence of knee pain and symptomatic OA in amputees vs. nonamputees

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Amputees (n=82)</th>
<th>Nonamputees (n=94)</th>
<th>Unadjusted Prevalence Ratio (95% CI)</th>
<th>Adjusted Prevalence Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Prevalence¹</td>
<td>N</td>
<td>Prevalence¹</td>
</tr>
<tr>
<td>Knee pain</td>
<td>26</td>
<td>40.3</td>
<td>19</td>
<td>20.2</td>
</tr>
<tr>
<td>Knee OA</td>
<td>10</td>
<td>16.1</td>
<td>11</td>
<td>11.7</td>
</tr>
</tbody>
</table>

*For age and average body weight.
¹Per 100 men.

Prevalence ratios similar to previous evidence on the subject.
Results

The prevalence of knee pain and symptomatic OA in amputees vs. nonamputees

The prevalence of knee pain among amputees and non amputees was 40.3% and 20.2% respectively.

The prevalence of symptomatic OA was 16.1% and 11.7% for amputees vs non amputees.
Results
The prevalence of knee pain and symptomatic OA in amputees vs. nonamputees

The prevalence of knee pain was 50% and 36.4% among transfemoral and transtibial amputees, respectively, compared to nonamputees.

Table 2: Absolute Prevalence and Crude and Adjusted Prevalence Ratios of Knee Pain and Symptomatic Knee OA Among Amputees and Nonamputees

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Amputees (n=82)</th>
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<th>Unadjusted Prevalence Ratio (95% CI)</th>
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<td></td>
<td>N</td>
<td>Prevalence¹</td>
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<tr>
<td>Knee pain</td>
<td>26</td>
<td>40.3</td>
<td>19</td>
<td>20.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.0 (1.2-3.3)</td>
</tr>
<tr>
<td>Knee OA</td>
<td>10</td>
<td>16.1</td>
<td>11</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.4 (0.6-3.0)</td>
</tr>
</tbody>
</table>

*For age and average body weight.
¹Per 100 men.
Discussion
The prevalence of knee pain and symptomatic OA in amputees vs. nonamputees

• Researchers believe the following may contribute to the secondary disability of knee pain or symptomatic OA:
  • Stresses on the contralateral knee of amputees
  • Increased loads on the knee of intact limb
  • Hopping behaviors

• Further studies are needed to explore:
  • Gait abnormalities; Stresses on intact limb and effects; Possible remedies
Limitations

• Retrospective study (i.e. reliability of subjects)
• Small sample size
• Population Bias (i.e. subjects gathered from outpatient database that required patients to have sought care thru the VA in the past 5 years)
• Possible misclassification of knee pain and OA (i.e. OA sometimes asymptomatic although radiograph reveals degeneration, and visa versa, etc)
"Strength asymmetry and osteoarthritis risk factors in unilateral transtibial amputee gait"

Lloyd CH, Stanhope SJ, Davis IS, Royer TD
Gait & Posture. 2010 Jul; 32(3): 296-300

• Objectives:
  • To assess the relationship between strength asymmetry and gait kinetics associated with the risk of osteoarthritis in transtibial amputees.

• Hypotheses:
  • Amputee strength and gait would be more asymmetric than controls and would positively correlate with gait variable asymmetry and intact side gait variables associated with OA risk and an increased magnitude of risk variables on intact limb.
Methods

• Three strength and three kinetic variables
• Eight unilateral, transtibial amputees and eight able bodied subjects
• All amputees subjects used patellar tendon prosthesis and able to ambulate without assistive device.
• The control subjects were matched by age, gender, and BMI and had no major LE injury/pathology.

Table 1
Subject demographics reported as group mean ± standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>TIA</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>8 (7.9)</td>
<td>8 (7.5)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>43 ± 13</td>
<td>45 ± 13</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.74 ± 0.07</td>
<td>1.76 ± 0.09</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>92 ± 8</td>
<td>96 ± 15</td>
</tr>
<tr>
<td>Speed (m/s)</td>
<td>1.2 ± 0.1</td>
<td>1.2 ± 0.1</td>
</tr>
<tr>
<td>Years using prosthesis</td>
<td>7.2 (range 0.5-23)</td>
<td>-</td>
</tr>
</tbody>
</table>
Methods

• **Three Strength Variables**
  - Knee Extension (KEXTs) peak torque
  - Knee Flexion (KFLEXs) peak torque
  - Hip Abduction (HABDs) peak torque
  - Nicolas MMT handheld dynamometer measured knee extensors, knee flexors, and hip abductor muscle groups.

• **Three Kinetic/Gait Variables**
  - Peak Knee External Adduction Moment (KEAMp) scaled to BW and Height
  - Maximum KEAM load rate (KEAMlr)
  - Maximum vertical GRF load rate (vGRFlr)
  - Eight digital camera system with integrated software sampling at 60 Hz
  - Subjects walked 10-m walkway at self-selected speed across force plate
Results
Kinetic Variables

- Max vertical GRF load rate (Figure A)
- Composite of knee adduction moment load rate and peak moment (Figure B)
  - The prosthetic limb (solid) had lowest mean load rate values for all three kinetic/gait variables
  - The amputee intact limb (dashed) had the highest mean load rate values for all three gait variables.
Results
Strength Variables

• Strength Variable Asymmetries
  • Knee flexion and knee extension strength was most asymmetrical between intact and prosthetic limbs of amputees
  • No asymmetries were found in hip abductor strength
Results
Correlations between Strength and Kinetic Variables

Knee extension versus KEAM load rate asymmetry.

Knee flexion asymmetry versus vertical GRF load rate on intact limb.
Discussion

**Strength Asymmetry**
- The significant strength asymmetry implies a gait compensation mechanism used by amputees that relies heavily on the intact limb
- Reduced prosthetic side quadriceps and hamstring strength may impair ability of prosthetic side limb to produce adequate propulsion

**Moment Avoidance Gait**
- Moment avoidance gait strategy results in increased load rates and muscular demands on the intact limb
- Possible that avoiding large moments as a protective measure on one limb may have detrimental effects on the contralateral limb
Limitations

• Self-selected walking speeds may have masked asymmetries.
• Small Sample size
• Possibility of error in knee joint and ankle joint kinetic calculations due to prosthesis design and difficulty in accurate marker placement. This would impact hip and knee joint moment calculations as well.
Conclusions – Clinical Question

Is a transfemoral amputation a predictor of an increased risk of developing knee osteoarthritis in the intact lower extremity?

Yes…

So what’s next?

Reduce the risk. Improve function.
Conclusions – My Patient
53 y/o male with R AKA s/p L TKA

- These studies offer insights that may be used to more specifically address my patients’ impairments and meet his goals, in addition, to raising important questions to consider for future research and clinical decisions:
  - **Strength asymmetries – Primary: Knee flexor and extensor groups**
    - How can PTs create Rx to prevent strength asymmetries in our amputee patients?
  - **Gait training – Moment avoidance, Educate**
    - How can PTs adjust gait training activities with amputees to reduce “moment avoidance” gait?
  - **Functional interference – Assessment, Educate**
    - How can PTs correctly assess our amputee patient’s level of interference in functional/social activities? Can PTs have an impact on improving their functional scores?
Works Cited

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QUESTIONS?