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Musculoskeletal Adaptations in Younger and Older Adults in Response to Challenging Conditions

Amanda K. Ivy
Boise State University

Amy E. Holcomb
Boise State University

Aidan G. Cormier

Clare K. Fitzpatrick
Boise State University

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Abstract

Accidental falls are the leading cause of injury in adults 65 years and older. Previous research has identified significant fall factors including cognitive distractions, environmental conditions, and physical impairments while current research is aimed on gaining a higher understanding of how the musculoskeletal system responds to these factors. We hypothesize that older adults who have experienced an accidental fall will have altered biomechanics during activities of daily living resulting in a stiffer knee and higher compressive load across the knee joint. Via computational modeling and medical imaging analysis, we aim to understand the correlation between knee stability and overall musculoskeletal function. This will enable us to work towards personalized treatment recommendations for improved joint stability including rehabilitation, orthotic development, or surgery intervention.

MUSCULOSKELETAL ADAPTATIONS IN YOUNGER AND OLDER ADULTS IN RESPONSE TO CHALLENGING CONDITIONS

Presenter: Amanda K. Ivy

Authors: Amanda K. Ivy, Amy E. Holcomb, Aidan G. Cormier, Dr. Clare K. Fitzpatrick

BOISE STATE UNIVERSITY

INTRODUCTION

The Centers for Disease Control estimates that one out of four adults over the age of 65 experiences an accidental fall each year and that by the year 2030, there will be an estimated seven deaths per hour due to accidental falls[1]. Previous research has identified some of the most significant risk factors for falls as being environmental conditions, cognitive distractions, and physical impairments. However, little is known about how the musculoskeletal system responds to these factors. Our current research is aimed at gaining an improved understanding of musculoskeletal adaptation by comparing the biomechanics of younger healthy subjects and older subjects who have experienced an accidental fall within the last year.

HYPOTHESIS: We hypothesize that older adults who have experienced an accidental fall will have altered biomechanics during activities of daily living resulting in a stiffer knee and higher compressive load across the knee joint.

APPROACH

Neuromechanical data collection of 28 subjects; 14 younger & 14 older

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Computational modeling via software platform, OpenSim

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Analysis of knee stability and overall musculoskeletal function between younger and older subjects

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Subject-specific joint stability modeling using OpenSim data, 3D imaging, finite element software, and COBR data

↓

Possible recommendations for surgical intervention, rehabilitation, or orthotic development

Completed | In Progress | Next Steps

Neuromechanical Data Collection

Figure 1: Subject in static pose with experimental markers during data collection

- Collaboration with Boise State Universities Center for Orthopaedic & Biomechanics Research Lab
- 36 Activity/surface/challenge experimental setups
- Three "good" trials per combination
- 108 total trials per participant

Surface Type
- Normal
- Slick
- Uneven

Activities
- Walk
- Pivot
- Stair Ascend
- Stair Descend

Additional Challenges
- Weighted vest
- Cognitive distraction

Computational Modeling

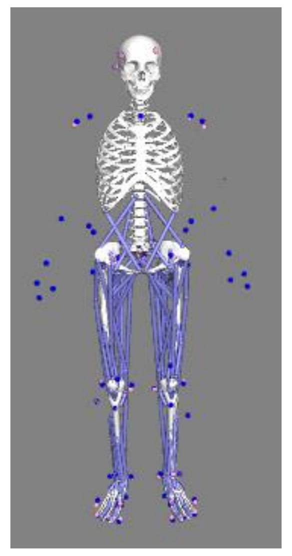

Figure 2: Computational model of subject with experimental markers in blue

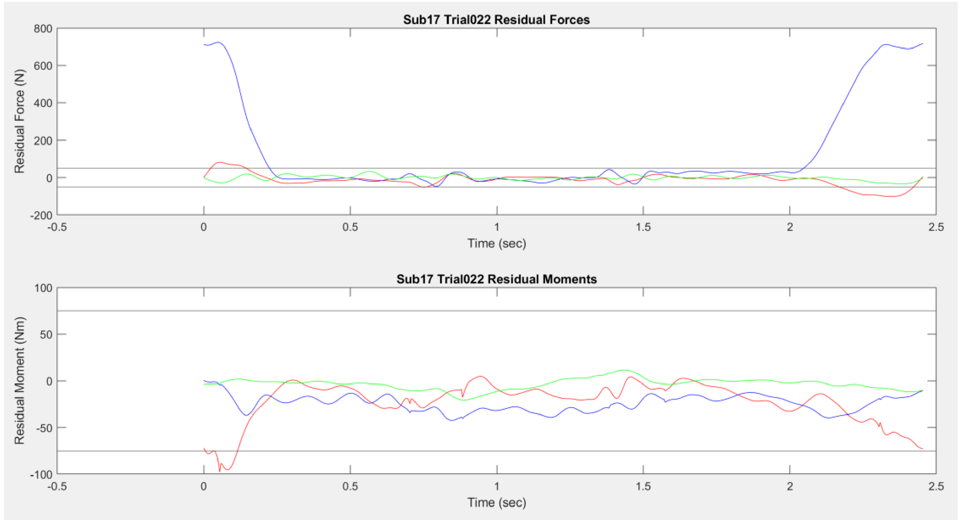

Figure 3: Residual forces, above, and residual moments, below, which is used to validate the accuracy of the computational model

Creating computational models of subjects allows for a greater understanding of how the musculoskeletal system responds to walking with challenging conditions. Using computational models, we can determine the degree of rotation and/or translation of joints, what muscles are activated during kinematics, and the corresponding net forces and moments associated with kinematics. The three main steps for creating a computational model are:

Scale
- Imports experimental marker data (Figure 1) from the COBR lab to create a computational model of the subject (Figure 2)

Inverse Kinematics
- Places the computational model in a position that best matches the experimental marker data for each timeframe of each trial
- Creates a file for each trial containing the joint angles and translations for each time frame of the trial to be used for analysis

Inverse Dynamics
- Determines the residual forces and moments for each trial (Figure 3) which is used to validate the accuracy of the computational model
- Creates a file for each trial containing the net forces and moments for each timeframe of the trial to be used for analysis

Analysis

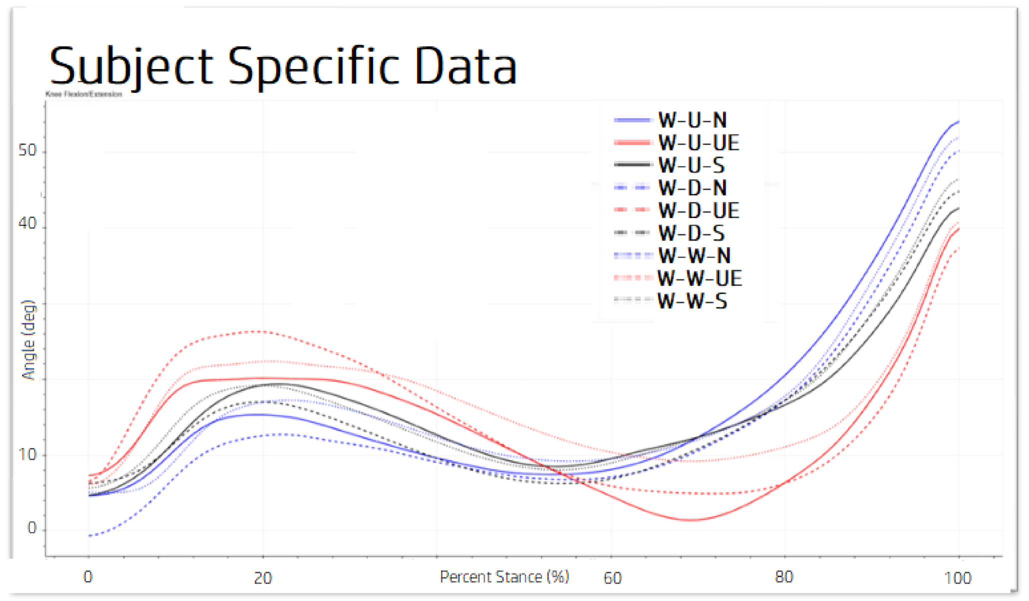

Figure 4: Plot showing knee flexion/extension angle with respect to percent of stance phase for a specific subject

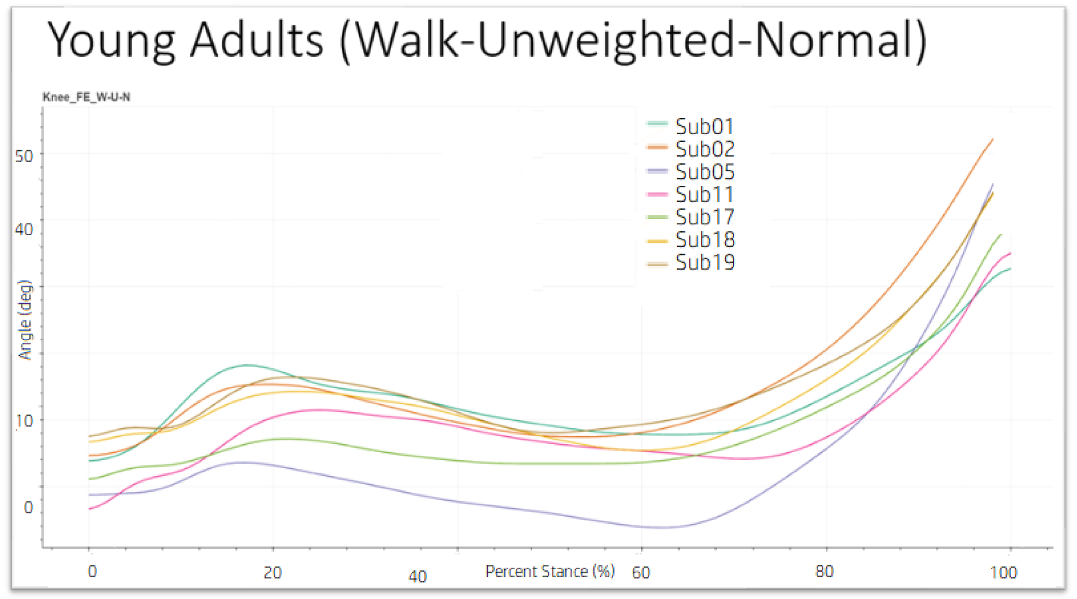

Figure 5: Plot showing the knee flexion/extension angle for all young adult subjects while walking unweighted on a normal surface with respect to percent of stance phase

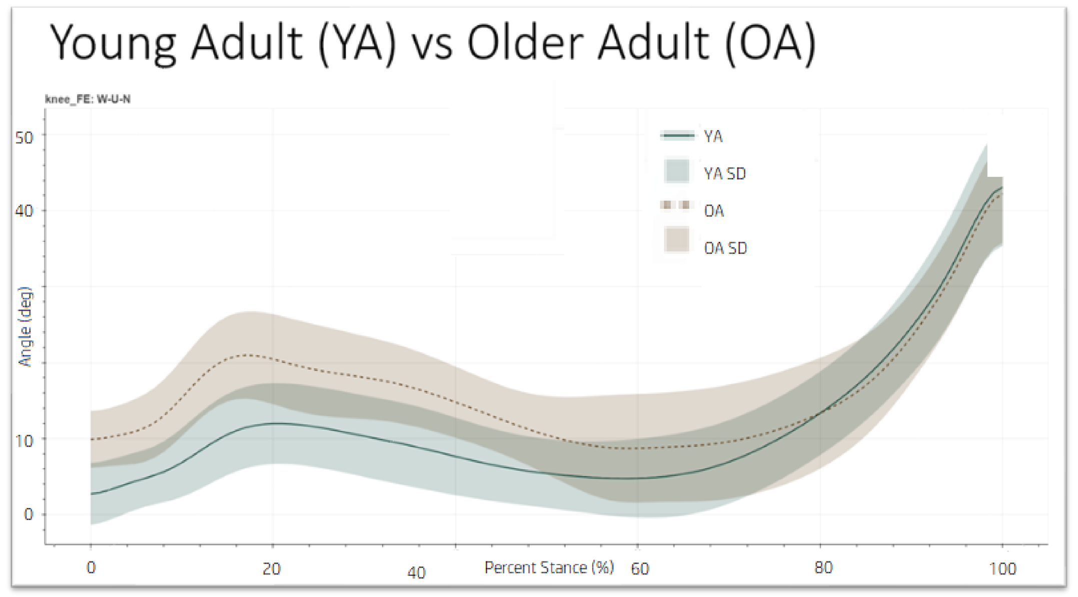

Figure 6: Plot showing knee flexion/extension comparison between the younger and older subjects while walking unweighted on a normal surface with respect to percent of stance phase

- Average the 3 trials per experimental setup & plot kinematics for each subject (Figure 4)
- Combine the subject specific data with the other younger adult (YA) or older adult (OA) subject data (Figure 5)
- Compare YA and OA data with respect to corresponding experimental setup (Figure 6)
- Extract metrics from joint kinematic data and run mixed model ANOVA (analysis of variance) to identify potential interaction effects

Future Direction

- Currently, all subject data has been collected
- 12 subjects need computational models constructed
- Upon completion of analysis of all 28 subjects, correlation between knee stability and musculoskeletal function will be quantified
- Subject-specific joint stability models will be created using OpenSim data, MRI imaging, and finite element software
- Findings may lead to musculoskeletal rehabilitation and injury prevention recommendations, orthotic development, or surgery intervention for subjects at risk from accidental falls
- Possible future research directed towards incorporating material properties of the articular cartilage of the knee joint to create further tailored subject-specific joint stability models

References:

1. Important Facts about Falls | Home and Recreational Safety | CDC Injury Center. Accessed March 30, 2021. https://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html

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