Orthopaedic Section of the APTA
Grant Program
Final Report Form

Date: 9/15/16

Name of Investigators: Audrey R.C. Elias, DPT, PhD, OCS; Ryan L. Mizner, PT, PhD
Name of Grant: A clinical trial to improve motor learning in plyometric training post-ACLR via a novel body-weight support system
Award Period: May 15, 2014 – April 30, 2016 (by no-cost extension)

1) Summary of major accomplishments of this project:
    - Thirty-five participants were screened for biomechanical and functional faults in landing. Of those, nineteen met inclusion criteria for the clinical trial and began training. Eighteen finished the 8-week training protocol, and all underwent retention testing 8 weeks later.
    - All treatment logs were analyzed by the hired treatment fidelity analyst, ensuring appropriately symmetrical treatment (in technical cueing, rest provided, progression of intensity, volume, and sport specificity, etc.) between groups.
    - All kinematic, kinetic, and electromyographic data was processed.
    - Kinematic, kinetic, electromyographic, and patient-reported function data was analyzed directed toward the primary questions of: 1) degree of improvement of knee flexion and moment, co-contraction of the hamstrings and quadriceps, and patient-reported function with jump training at high and low volumes; 2) differential effect of high volume with body weight support and low volume without body weight support on the retention of improvements in the above-mentioned measures; 3) differential effect of high volume training with body weight support and low-volume training without body weight support on joint tolerance to training as measured by a stroke test for effusion.
    - Two papers pertaining to the project were published. One paper validated the body weight support system as a training adjunct. The other was a case study based on a participant in this trial.
    - Two additional papers have been submitted and are in review. One utilizes data from the screening examinations of 30 of the participants in this study combined with data from another study to examine the effect of mechanism of injury on neuromuscular patterning following reconstruction. The other presents the results of the trial, specifically related to changes in and retention of knee flexion angle, knee moment, vertical ground reaction forces, and co-contraction of the hamstrings and quadriceps during landing, as well as functional measures including single leg hop for distance and patient-reported function as measured by the IKDC questionnaire.
    - An abstract of the latter paper was also submitted to and accepted for platform presentation at the 2017 Combined Sections Meeting of the APTA.

- Processing and analysis of gluteal activation in landing before and after training is ongoing and the focus of the next paper from the dataset generated by the work supported by this grant.

2) One-paragraph summary of results or abstract suitable for posting on the Orthopaedic Section website:

Abnormally limited knee flexion and increased co-contraction of the quadriceps and hamstrings during jump landing are thought to contribute to second anterior cruciate ligament (ACL) injuries and development of knee osteoarthritis (OA) following ACL reconstruction. Jump training, undertaken at low repetition for safety, is frequently part of rehabilitation, though its effect on mechanical and neuromuscular deficits following ACL reconstruction is unknown. The Bodyweight Reduction Instrument to Deliver Graded Exercise (BRIDGE) reduces impact forces during jumping tasks and allows investigation into the effect of higher volume jump training on weight acceptance, knee flexion, and neuromuscular patterns during jump landing. We hypothesized that jump training would improve patient-reported functional, mechanical, and neuromuscular outcomes, and that higher repetition training augmented by the BRIDGE body weight support system would results in improved retention of gains. Thirty-two individuals (averaging 18 months post-surgery) were screened and 19 athletes with mechanical deficits and limited clinical outcomes were enrolled in this randomized pragmatic trial. Testing included the International Knee Documentation Committee (IKDC) Questionnaire, leg landing mechanics via motion analysis, knee joint effusion using a stroke test, and a surface electromyography-generated co-contraction index during a single leg landing. Participants were randomly assigned to one of two training groups: jump training with normal body weight (STANDARD), and jump training on the BRIDGE system (BRIDGE). The BRIDGE body weight support system allowed higher repetition of training activities over the 8-week training period. Changes in outcomes were modeled through the training period with a mixed-effects model with main effects of time, group, and gender, and a random effect of subject. Immediate outcomes were compared with those at 8 weeks following completion of training with two-way ANOVAs with effects of time and group. Effect sizes were calculated using Cohen's *d* and 95% confidence intervals were generated. There were significant effects of time during the training phase (weeks 0-8) for all outcome measures, but no effects of group or gender. Average IKDC score increased from 76%±12% to 87%±8% (mean±SD; d=1.12; β=1.4, p<0.001). Knee flexion during single leg landing increased from 57°±11° to 73°±9° (d=1.64; β=2.01, p<0.001). Average co-contraction index decreased from 37±15 to 19±6 (d=1.26; β=-2.17, p<0.001). All measures were retained over the 8-week retention period in both groups. The relative risk of knee effusion of the STANDARD0 group to the BRIDGE group was 4.2 (95%CI (2.25, 7.71); probability of effusion: STANDARD=0.16; BRIDGE=0.04). Jump training effectively mitigates risk factors for second injury and osteoarthritis in patients following ACL reconstruction. Gains in mechanical and neuromuscular coordination deficits are reflected in lasting improvements in function and performance. High repetition with body weight support did not improve retention, but may be safer for joint structures. The current work provides strong evidence that jump training is an effective intervention for people with poor outcomes following ACL reconstruction, while training with body weight support may lessen the impact on joint structures.

3) Attach a list of your publications published or accepted during the past year, or currently being written. Send reprints when available. List presentations made and abstracts accepted for presentation based on this work. Indicate with an asterisk (*) those publications supported by Orthopaedic Section funding.

Peer-Review Publications

- * Elias ARC, Kinney AE, Mizner RL. High volume jump training coupled with body weight support in a patient with anterior cruciate ligament reconstruction: A case report. Int J Sports Phys Ther. 2015 Dec;10(7):1035-49
- Elias ARC, Hammill CD, Mizner RL. The effect of body weight support on kinetics and kinematics of a repetitive plyometric task. J Appl Biomech. 2016 Feb;32(1):69-77
- * Elias ARC, Mizner RL. Neuromuscular patterning following anterior cruciate ligament reconstruction varies with mechanism of injury. Scand J Med Sci Sport. IN REVIEW
- * Elias ARC, LaStayo P, Harris KJ, Mizner RL. Clinic efficacy of jump training augmented with body weight support following ACL reconstruction. Am J Sports Med. IN REVIEW

Presentations Made

- * Elias ARC, Mizner RL. Mechanical and neuromuscular changes with jump training following ACL reconstruction. Platform Presentation, Combined Sections Meeting of the American Physical Therapy Association (APTA) in Anaheim, CA, 2016.
- * Mizner RL, Elias ARC. Differential influence of knee pain with activity on patient-reported versus performance-based outcomes after anterior cruciate ligament reconstruction. Poster Presentation, Combined Sections Meeting of the American Physical Therapy Association (APTA) in Anaheim, CA, 2016.

Abstracts Accepted

- * Elias ARC, LaStayo P, Harris KJ, Mizner RL. Clinical effectiveness of jump training augmented with body weight support following ACL reconstruction. Accepted for Platform Presentation, Combined Sections Meeting of the American Physical Therapy Association (APTA) in San Antonio, TX, 2017.

4) Provide a budget, using the original approved budget. Indicate total funds spent to date per major categories. If there was a ≥25% deviation (greater or less spent) of use of funds for any of the budget categories, please BRIEFLY indicate the rationale.

Expense Category	Budgeted	Actual Period 1	Actual Period 2	Actual Period 3	Total
Investigator Salary	4143	4143	0	0	4143
Clinical Salary	5152	560	850	0	1410
Contract Services	3633	250	115	7142	7507
Materials & Supplies	2065	1289	502	142	1933
Total	**14993**	**6242**	**1467**	**7284**	**14993**

The clinician hired to perform treatments was unable to perform as many as anticipated, decreasing the actual disbursement in clinical salary. To mitigate for any problems with treatment fidelity, the

budget from clinical salary was transferred into Contract Services, to pay for additional fidelity analysis. Further, additional work was needed to process electromyographic data than was anticipated, increasing the Contract Services budget further.

PT OCS.

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Signature Date