THE UNIVERSITY of TENNESSEE CHATTANOOGA

OPTIMAL-PREP AND ITS EFFECTS ON QUADRICEPS FORCE DEVELOPMENT IN PATIENTS WITH ACL-R

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Introduction

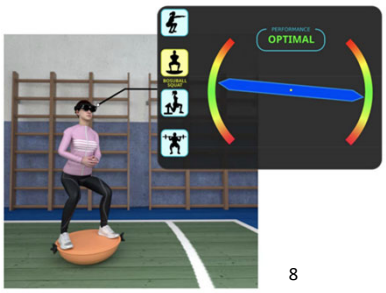
- Rate of re-injury following anterior cruciate ligament reconstruction (ACL-R) is as high as 33% [1]
- Dysfunctional quadriceps are associated with poor injury outcomes [2,3]
- ACL-R rehabilitation typically focuses on local joint function [4]
- Holistic motor learning principles may enhance quadriceps function [5]
  - Quadriceps Peak Torque (QPT)
  - Rate of Force Development (RFD)

OPTIMAL-PREP

- Optimizing Performance Through Intrinsic Motivation and Attention for Learning - Prevention Rehabilitation Exercise Play [6]
- Motivational Pillars
  - Enhanced Expectancy (EE)
  - Autonomy Support (AS)
- Attentional Pillar
  - External Focus (EF)

OPTIMAL-PREP

- Enhanced Expectancy
  - Providing positive outlook to increase belief in future success [7]
- Autonomy Support
  - Opportunities for self choice increases the likelihood of positive outcomes and can also increase self efficacy and intrinsic motivation [7]
- External Focus
  - Externally focused rehabilitation may enhance skill and better prepare athletes for return to sport [7]



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Hypotheses

- OPTIMAL-PREP will result in greater quadriceps and hamstrings peak torque and rate of force development compared to control condition
- OPTIMAL-PREP will result in greater improvement in quadriceps and hamstrings peak torque and rate of force development in the ACL-R limb compared to the uninvolved limb

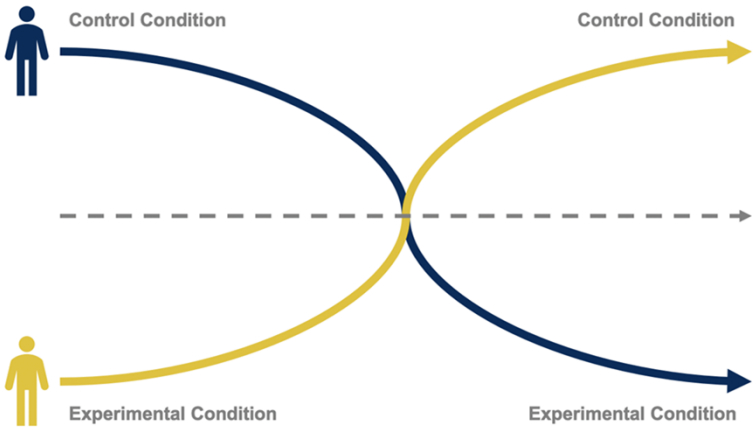
Participants

- Demographics
  - Age - 22.5 ± 2.98 y/o
  - Weight - 71.5 ± 13.44 kg
  - Height - 170.67 ± 8.34 cm
  - 3 males, 10 females
  - 10 noncontact, 3 contact
  - 23 ± 19 months post surgery
- Inclusion Criteria
  - Cleared for all participation in sports/ADLs
  - Over age of 18
- Exclusion Criterion
  - Re-injury or contralateral tear
- IKDC (80.02 ± 8.71), Tegner (7.54 ± 1.51), Lysholm (91.46 ± 8.49)
- IRB written informed consent was obtained

IRB #22-083

Study Design

- Randomized Crossover Study

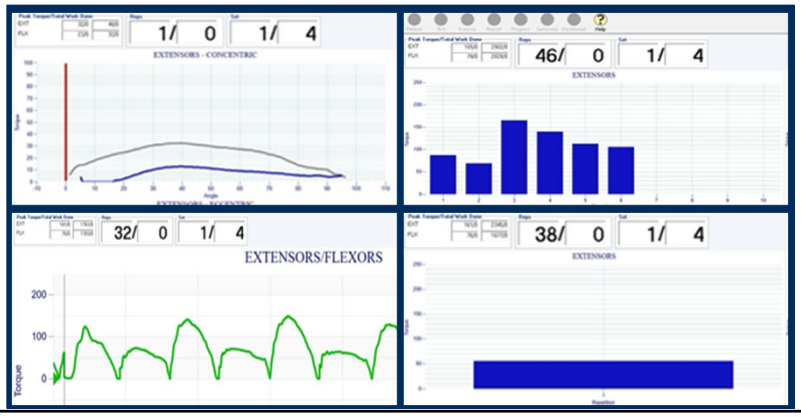


Methods

- Participants' quadriceps and hamstrings function were tested using a Biodex Isokinetic Dynamometer with Humac NORM software
  - Protocol
    - Tested non-affected limb first on all participants
    - 60 deg/sec isokinetic test
    - Practice trial for familiarization
    - For all trials, instructed to perform 5 reps "as hard and fast as possible" (both conditions)

Delivery of OPTIMAL-PREP

- EE and EF
  - "Research shows that if you focus on moving this line/bar you will exhibit greater quadricep output."
- AS - choice of graph



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Data Processing

- Humac NORM filters data with a 416Hz anti-aliasing filter
- Absolute peak was taken among 5 repetitions
  - Peak Newton meters (Nm)
  - Peak Nm normalized to body mass (Nm/kg)
  - Angle at peak Nm (°)
  - Time to peak Nm (sPk)
  - Time held at peak Nm (sH)
- All variables obtained for quadriceps and hamstrings in all four conditions

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Statistical Analysis

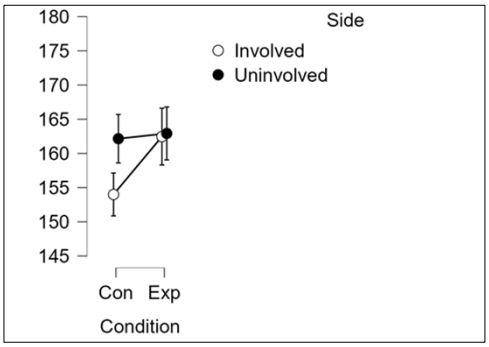
- Assessed data for normality with histograms
- Four 2x2 (side by condition) within subject repeated measures ANOVAs
  - Peak torque for quadriceps and hamstrings (Nm)
  - Rate of force development (Nm/s/kg) for both quads and hams
- As an exploratory pilot study, we set an a priori effect size of $\eta_p^2 = 0.06$ (moderate effect)

Results – Quadriceps Peak Torque

- OPTIMAL-PREP resulted in improved quadriceps peak torque in involved leg but not the uninvolved leg

	$F_{(df)}$	p value	η_p^2
Side	0.69	0.42	0.06
Condition	3.66	0.08	0.23
Side x Condition	1.77	0.21	0.13

Side	Condition	Mean ± SD
Involved	Con	154.00 ± 39.95
	Exp	162.46 ± 43.42
Uninvolved	Con	162.15 ± 27.90
	Exp	162.92 ± 34.28

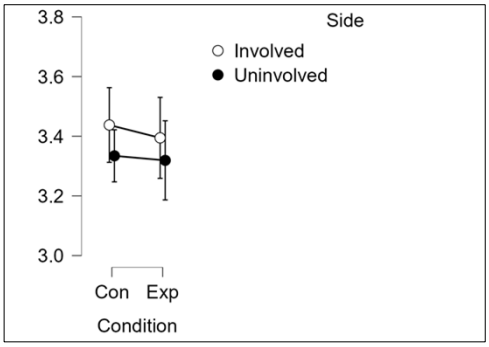


Results - Quadriceps RFD

- OPTIMAL-PREP had no influence on side or condition for quadriceps RFD

	$F_{(df)}$	p value	η_p^2
Side	0.26	0.62	0.02
Condition	0.21	0.66	0.02
Side x Condition	0.02	0.89	0.001

Side	Condition	Mean ± SD
Involved	Con	3.44 ± 1.35
	Exp	3.40 ± 1.39
Uninvolved	Con	3.33 ± 1.00
	Exp	3.32 ± 0.97



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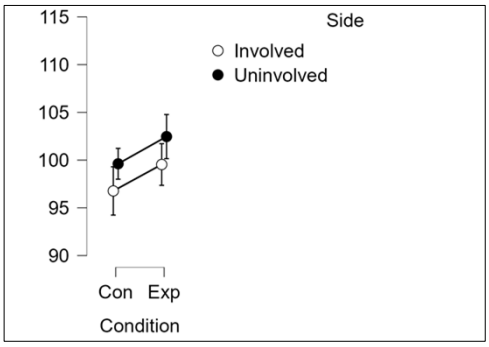
Results - Hamstrings Peak Torque

- OPTIMAL-PREP Improved hamstring peak torque in both the involved and uninvolved leg

	$F_{(df)}$	p value	η_p^2
Side	1.71	0.22	0.13
Condition	1.25	0.29	0.10
Side x Condition	4.65E-04	0.98	3.88E-05

Side	Condition	Mean ± SD
Involved	Con	96.77 ± 19.95
	Exp	99.54 ± 21.47
Uninvolved	Con	99.62 ± 19.43
	Exp	102.46 ± 16.75



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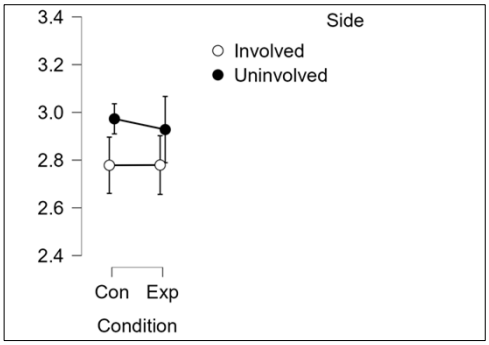
Results - Hamstrings RFD

- OPTIMAL-PREP had no influence on ham RFD; however, the uninvolved side demonstrated higher RFD.

	$F_{(df)}$	p value	η_p^2
Side	1.48	0.25	0.11
Condition	0.04	0.84	0.11
Side x Condition	0.06	0.81	0.001

Side	Condition	Mean ± SD
Involved	Con	2.78 ± 0.84
	Exp	2.78 ± 0.93
Uninvolved	Con	2.97 ± 0.83
	Exp	2.93 ± 0.84



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Discussion

- Quadriceps function is known to be deficient in ACL-R limbs [9]
  - Previous literature 2.48 ± 0.65 Nm/kg (injured) 2.87 ± 0.58 Nm/kg (healthy) [10]
  - Our observed values were 2.17 ± 0.49 Nm/kg (injured) 2.29 ± 0.35 Nm/kg (healthy)
  - Predictor of second ACL injury and osteoarthritis [11]
    - Motor and sensory deficits can impact ability to react to forces
    - Inability of quad to attenuate ground reaction forces during walking
- No effect of side or condition for RFD

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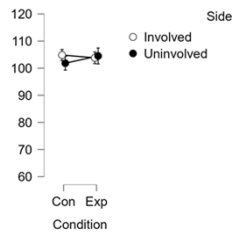
Discussion – Quad Peak Torque

- We observed an interaction for quadriceps absolute peak torque
  - OPTIMAL - PREP condition benefited involved leg
  - Average 8 Nm benefit on ACL-R limb ($p=0.21$, $\eta_p^2 = 0.13$)
- OPTIMAL-PREP is thought to increase dopaminergic transmission via motivational pillars [12]
  - Increased motivation
  - Increased engagement
  - Theorized that motivation may increase motor/efferent drive to the musculature

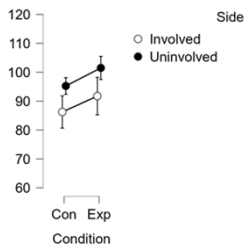
Discussion – What Did OPTIMAL-PREP Improve?

- Improved quadriceps and hamstrings peak torque
  - Quadriceps effect is driven by involved leg
  - Increased hamstrings peak torque in both limbs by 3 Nm
- Administering OPTIMAL-PREP to patients with hamstring grafts might be beneficial

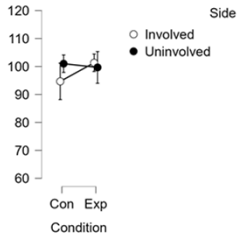
Allograft



Hamstring



Patellar



Clinical Relevance

- Use external focus during strength testing
  - Improves quadricep peak torque in involved limb
- May be more beneficial in patients with hamstring grafts
  - Hamstring peak torque in both limbs improved with motor learning
- Feedback and choice might be beneficial for force output

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